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Mizutani

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(54) **GOLF CLUB HEAD**

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(22) Filed: **May 20, 2014**

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(30) **Foreign Application Priority Data**

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A63B 53/06 (2015.01)
A63B 53/04 (2015.01)
A63B 71/06 (2006.01)

(52) **U.S. Cl.**
CPC ***A63B 53/06*** (2013.01); ***A63B 53/0466*** (2013.01); *A63B 2053/0433* (2013.01); *A63B 2053/0491* (2013.01); *A63B 2071/0694* (2013.01); *A63B 2225/09* (2013.01)

(58) **Field of Classification Search**
CPC A63B 2053/0491; A63B 2053/0433; A63B 53/06
USPC 473/338, 335, 336, 337, 339, 349
See application file for complete search history.

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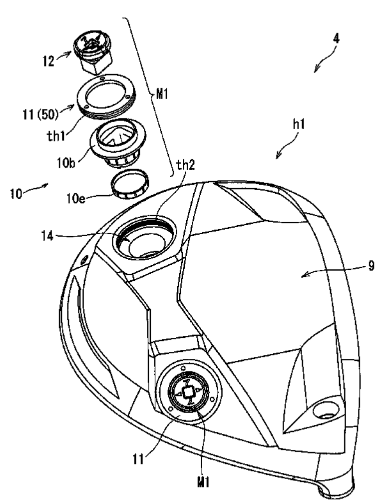
(57) **ABSTRACT**

A head **4** includes a head main body h**1**, a socket **10**, an attachment member **11**, and a weight body **12**. The head main body h**1** includes a socket housing portion **14**. The socket **10** is attached to the socket housing portion **14**. The socket housing portion **14** includes a first opening K**1** through which the socket **10** can be housed. The attachment member **11** is mechanically joined to the head main body h**1**. The attachment member **11** is disposed so as to block at least a part of the first opening K**1**. The attachment member **11** controls the falling off of the socket **10** from the first opening K**1**. The socket **10** includes a held portion **10***b*. The held portion **10***b* is pressed by the attachment member **11**. The socket **10** is formed of a polymer.

12 Claims, 26 Drawing Sheets



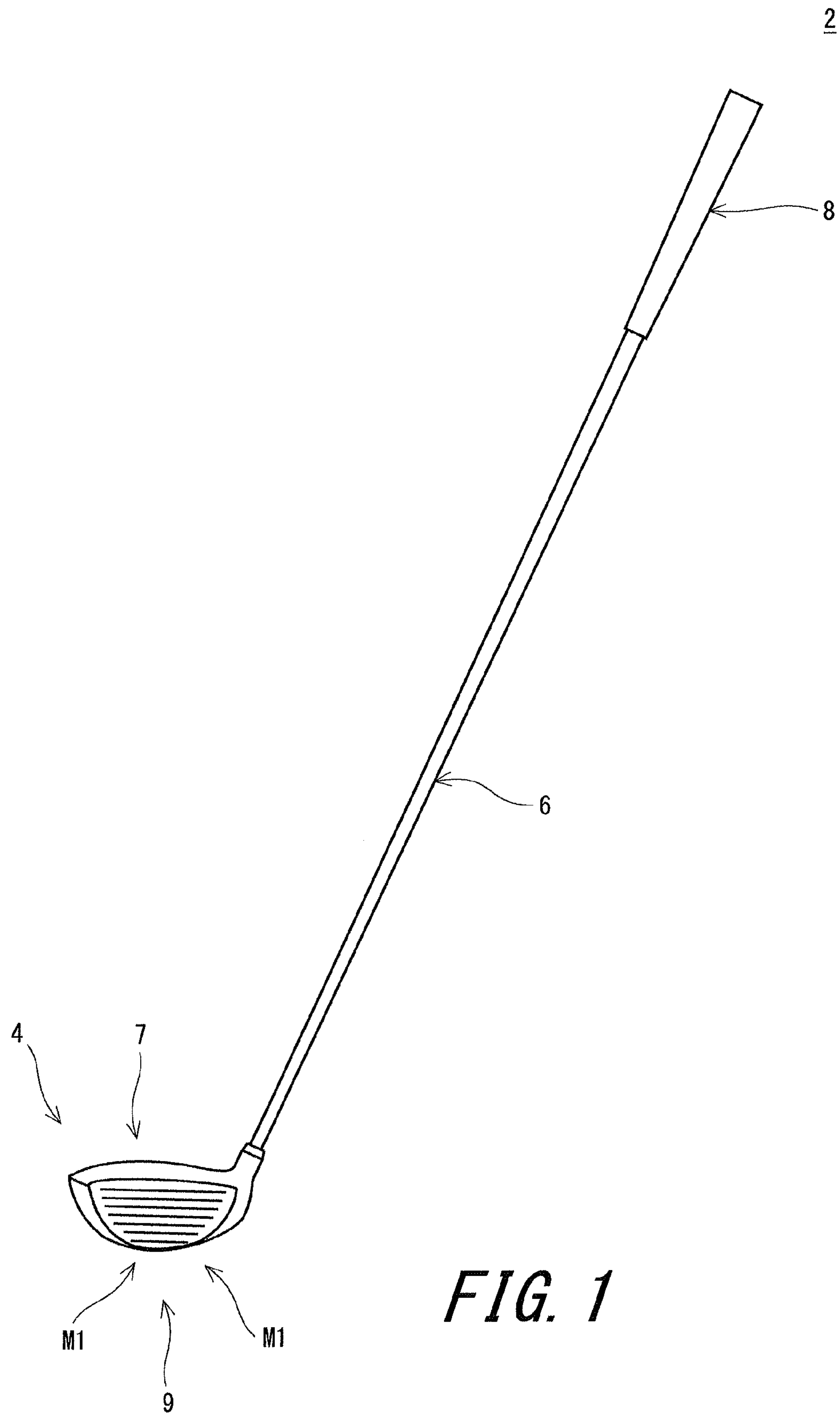


FIG. 1

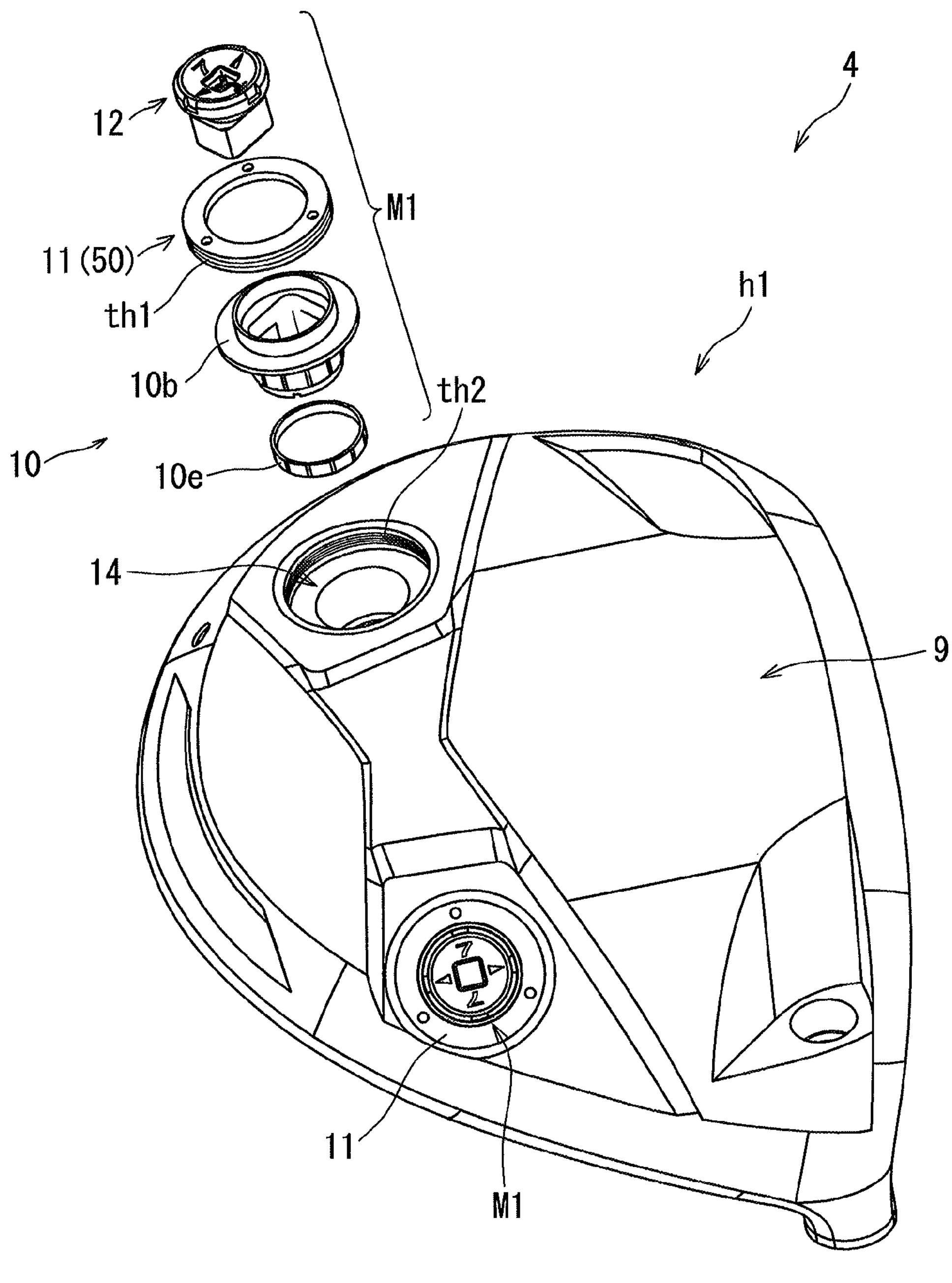


FIG. 2

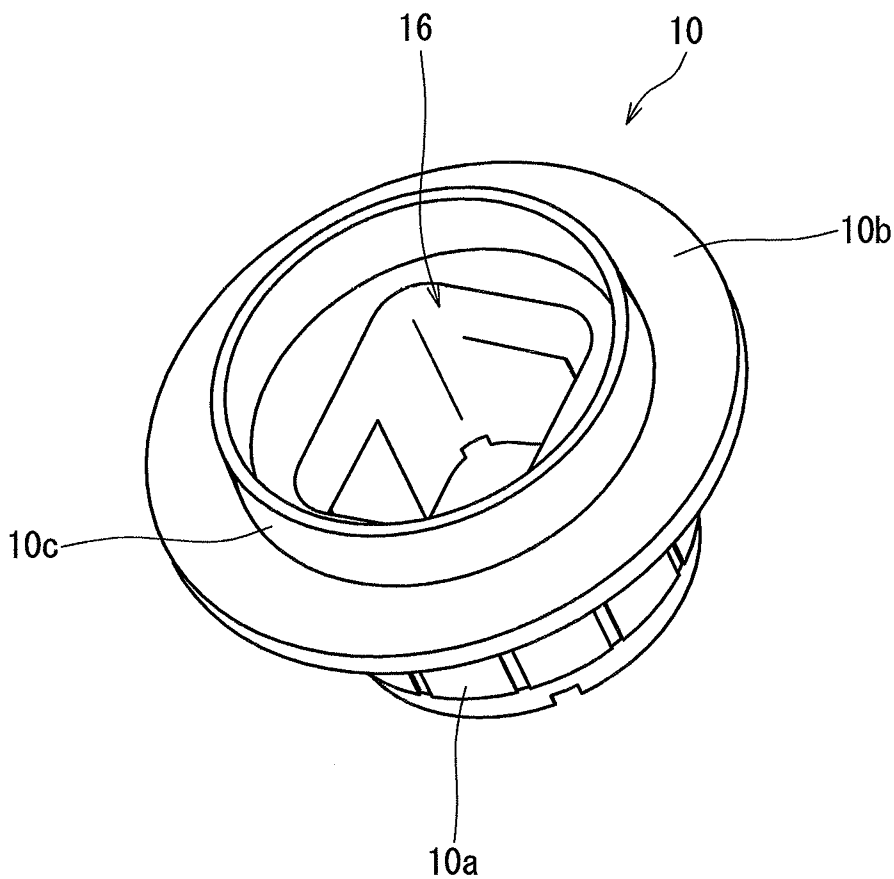


FIG. 3

FIG. 4A

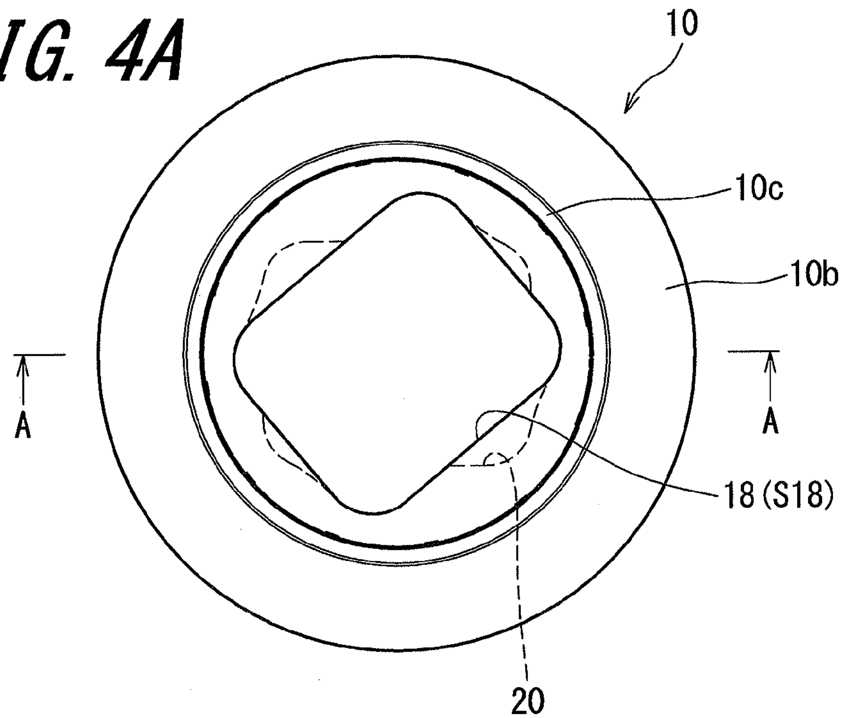
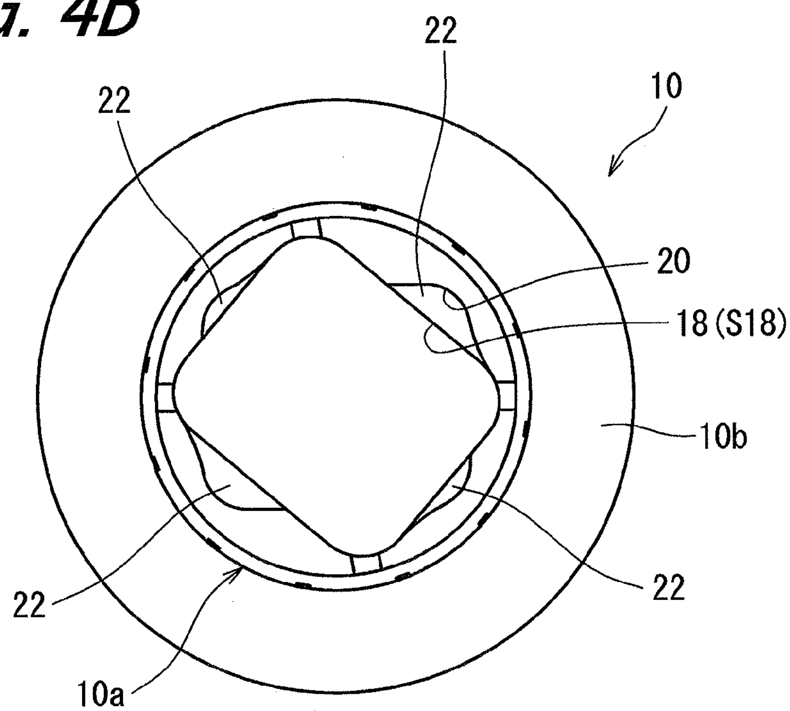
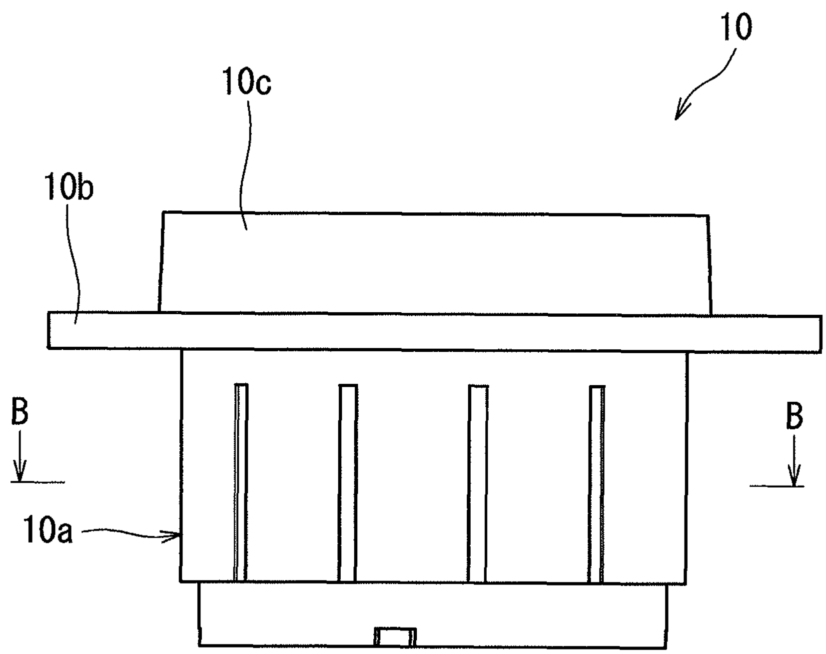


FIG. 4B





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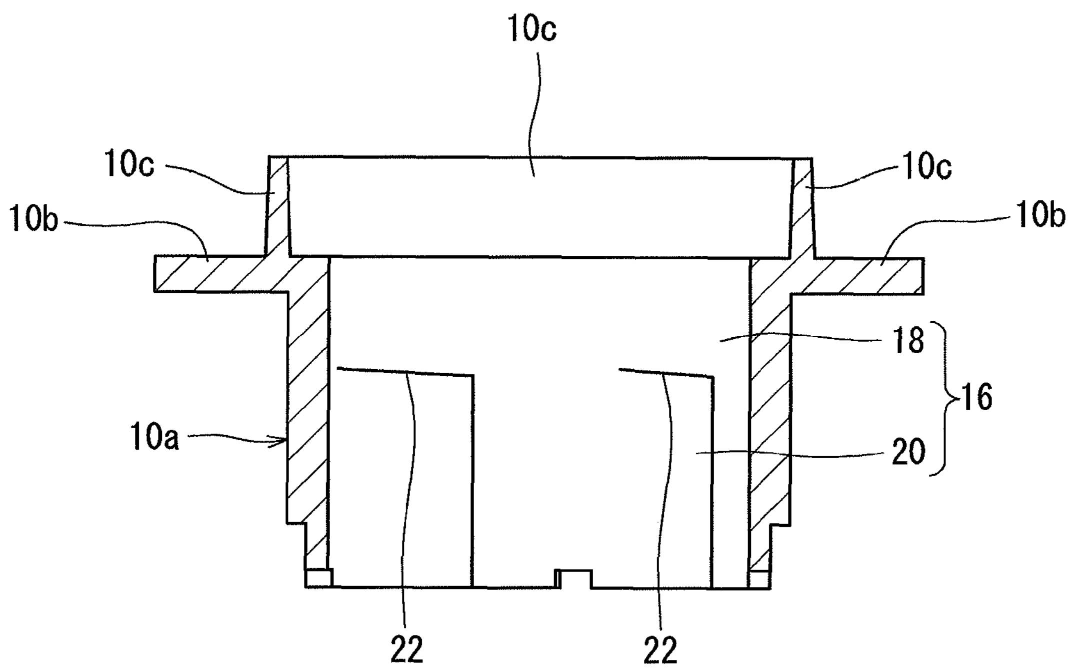

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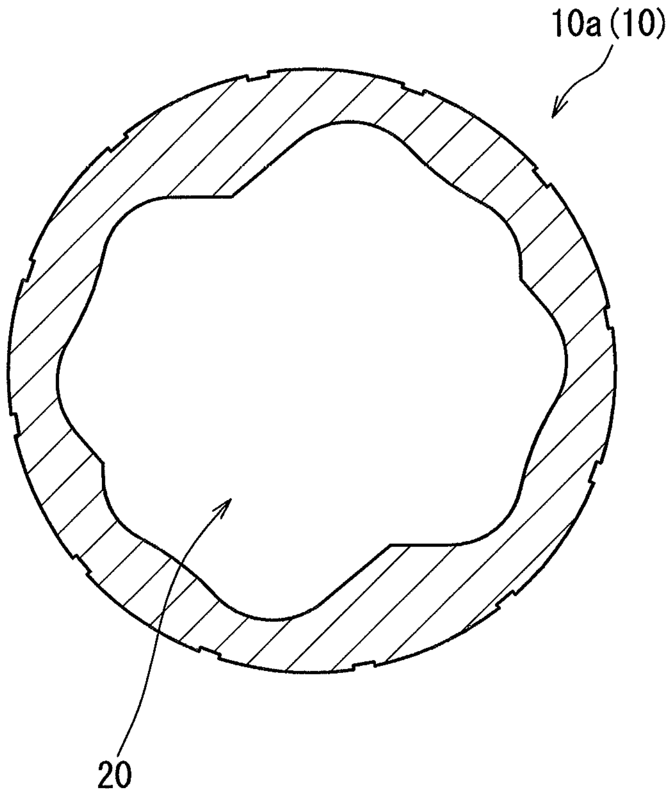

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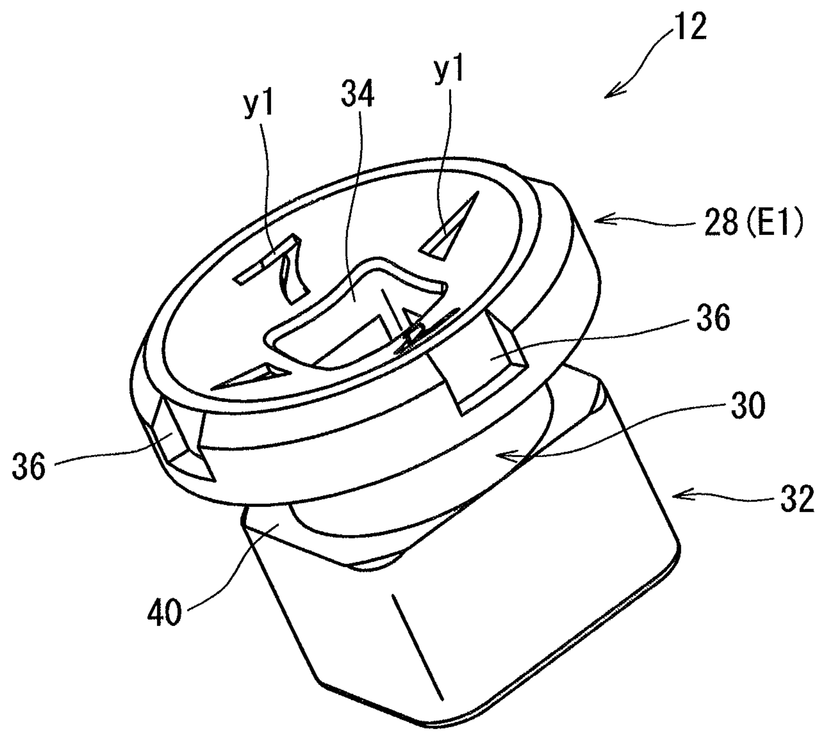


FIG. 8

FIG. 9A

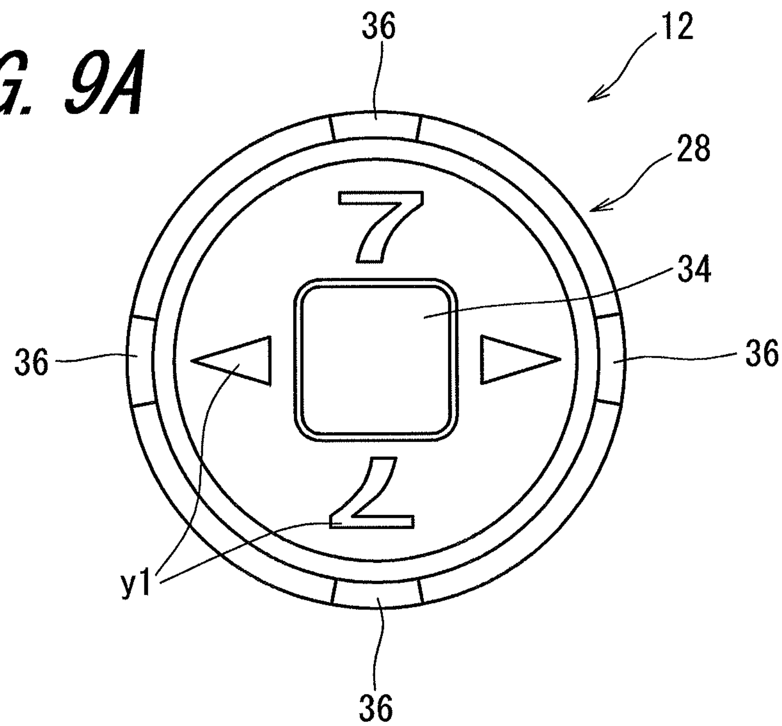


FIG. 9B

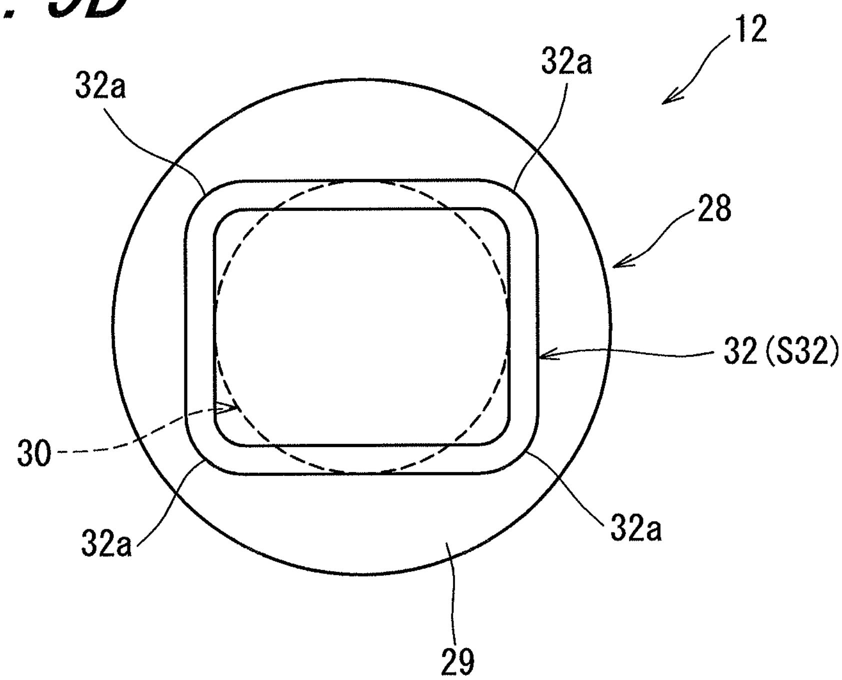


FIG. 10A

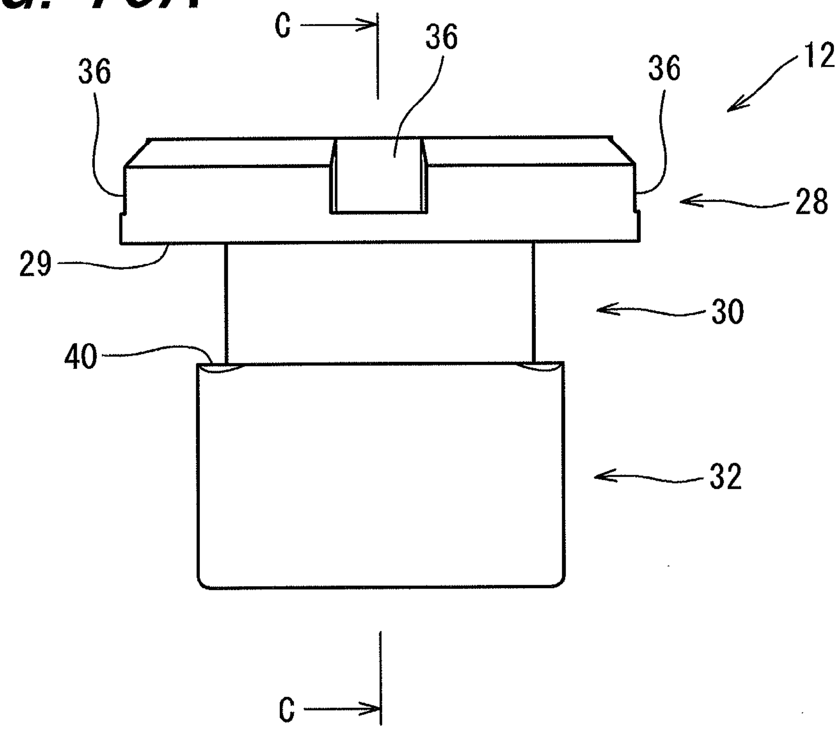
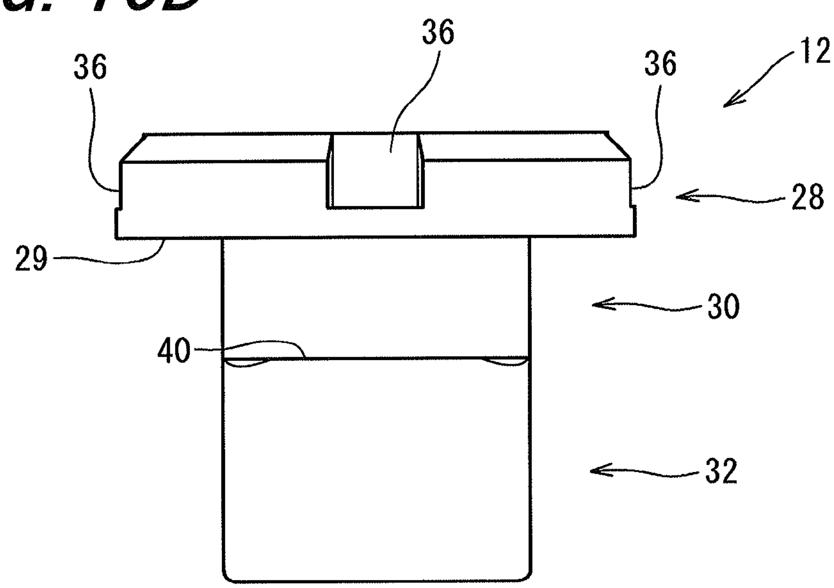
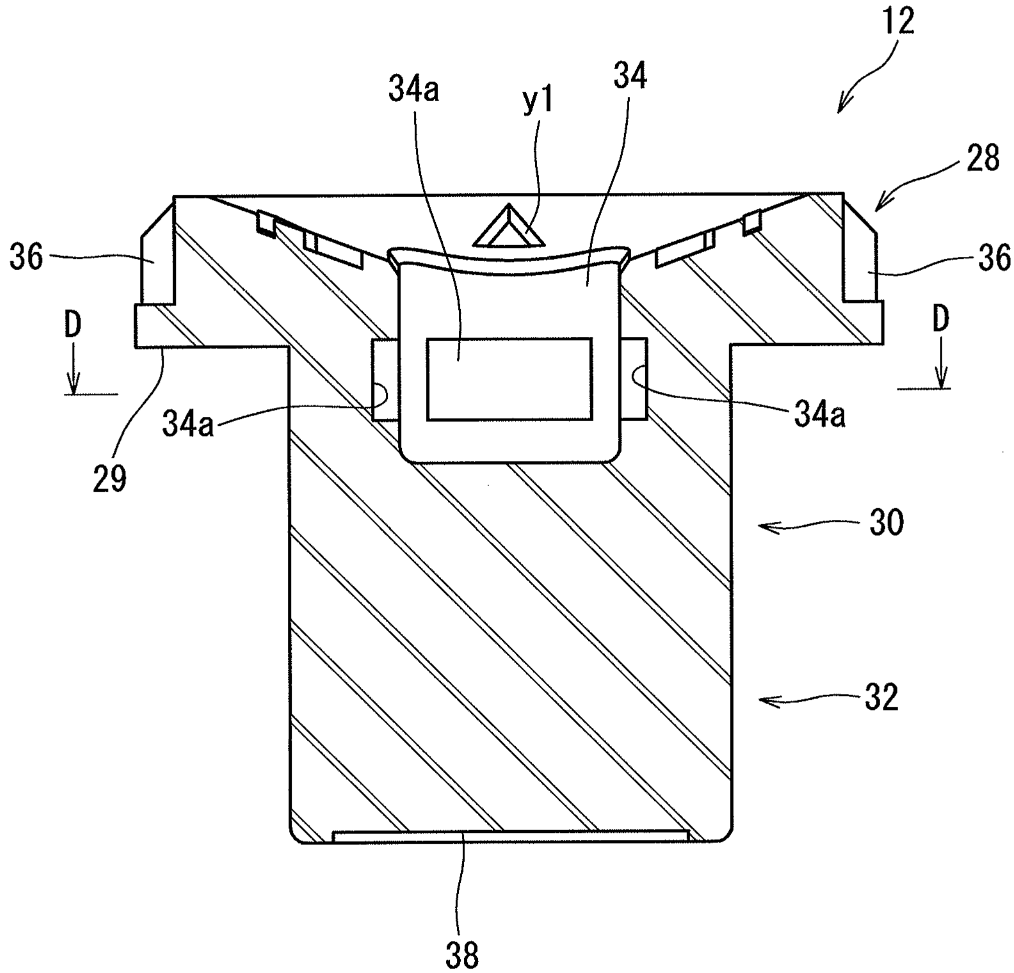


FIG. 10B





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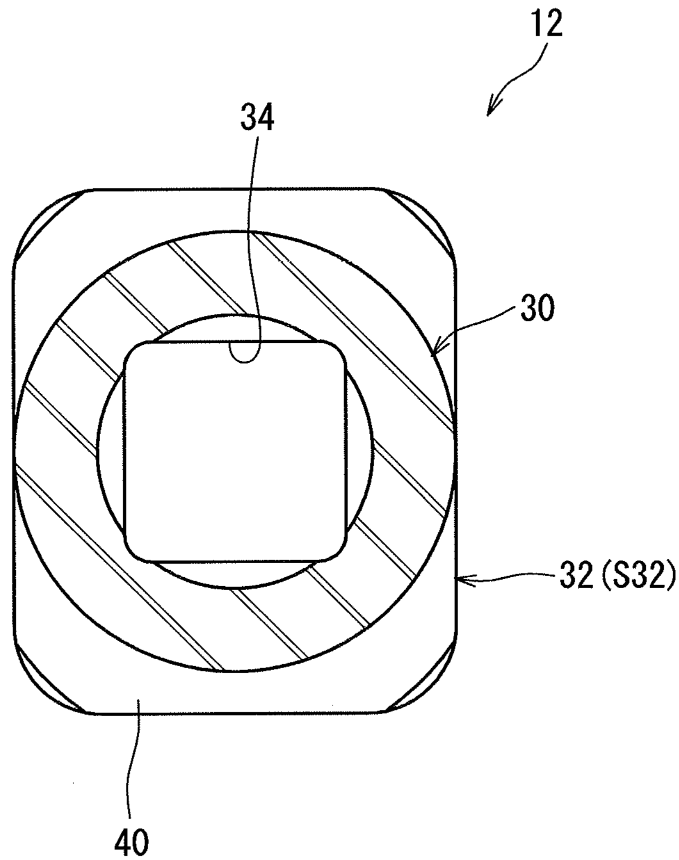


FIG. 12

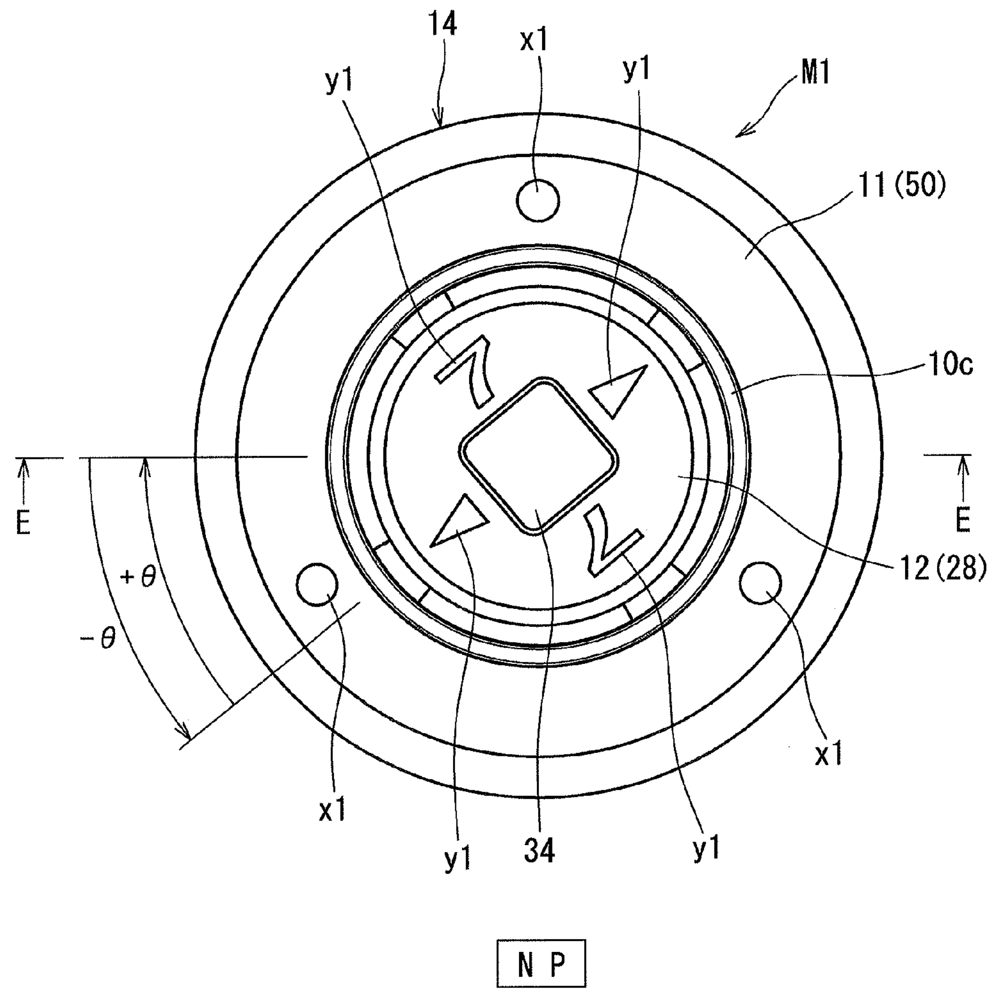


FIG. 13

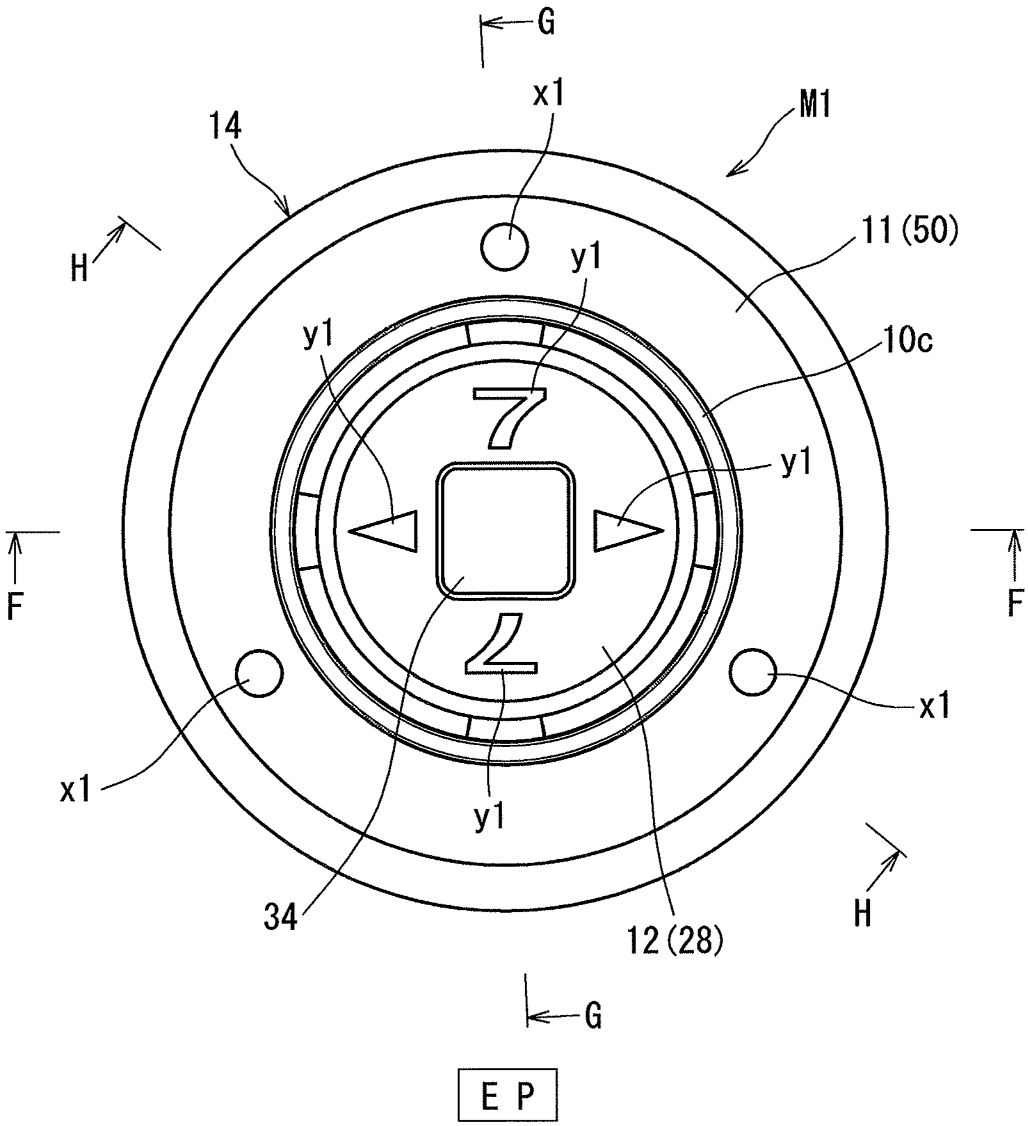


FIG. 14

FIG. 15A

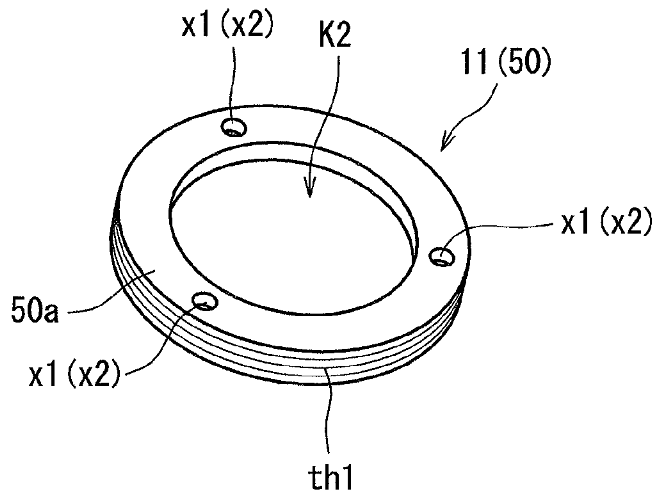
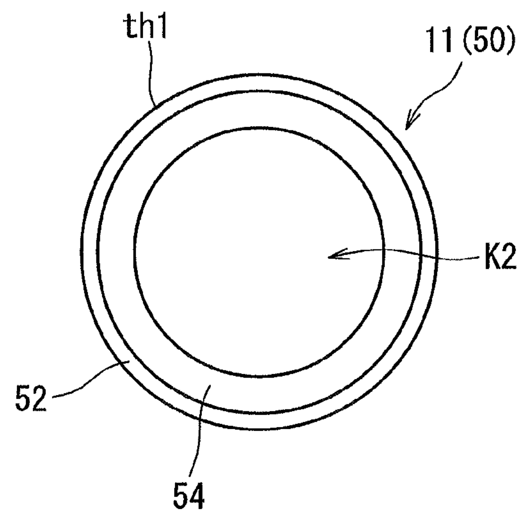


FIG. 15B



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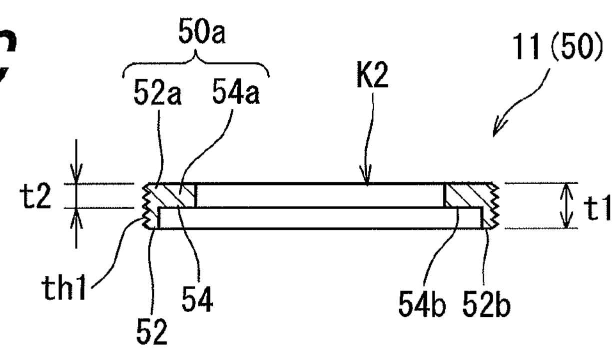


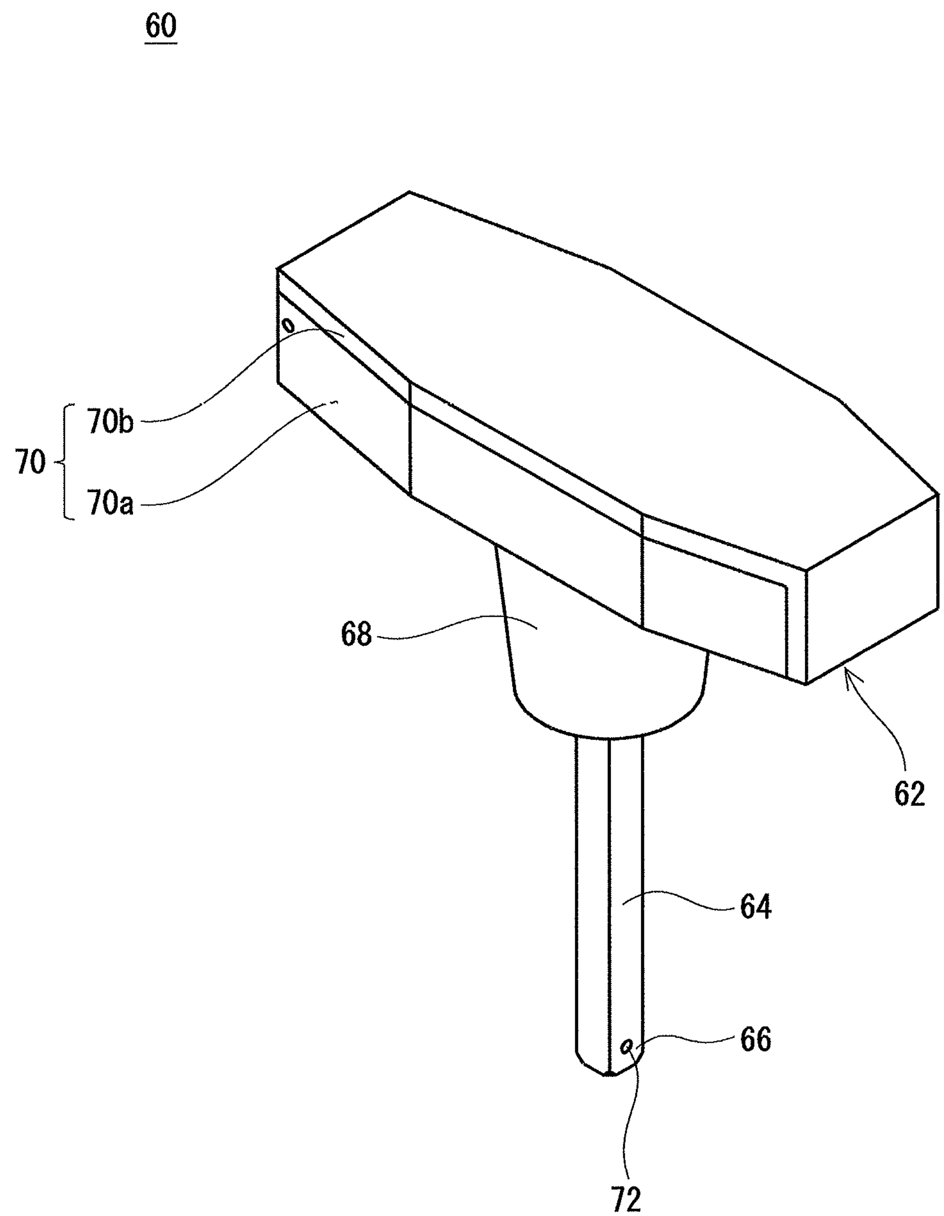


FIG. 16

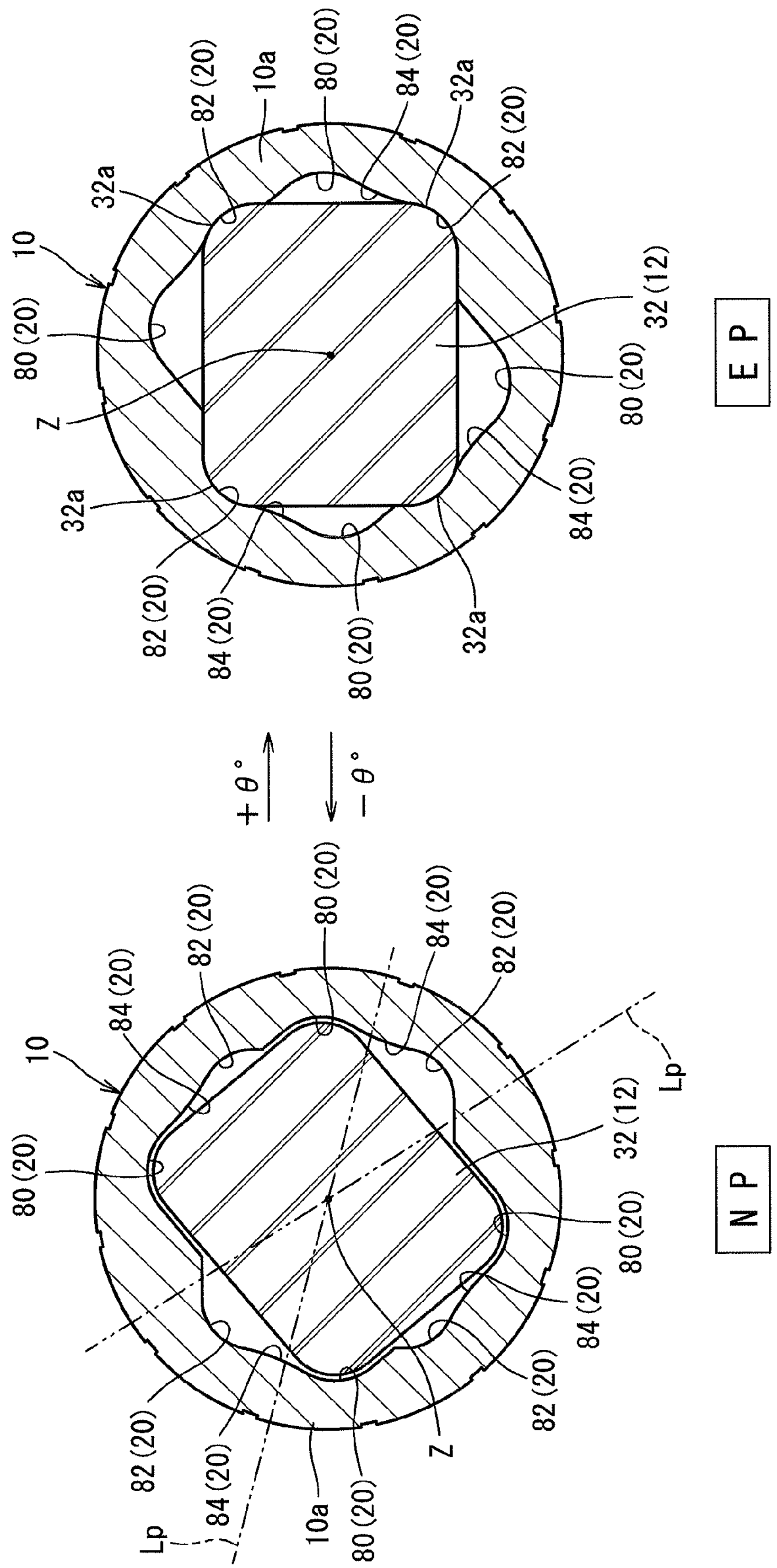


FIG. 17

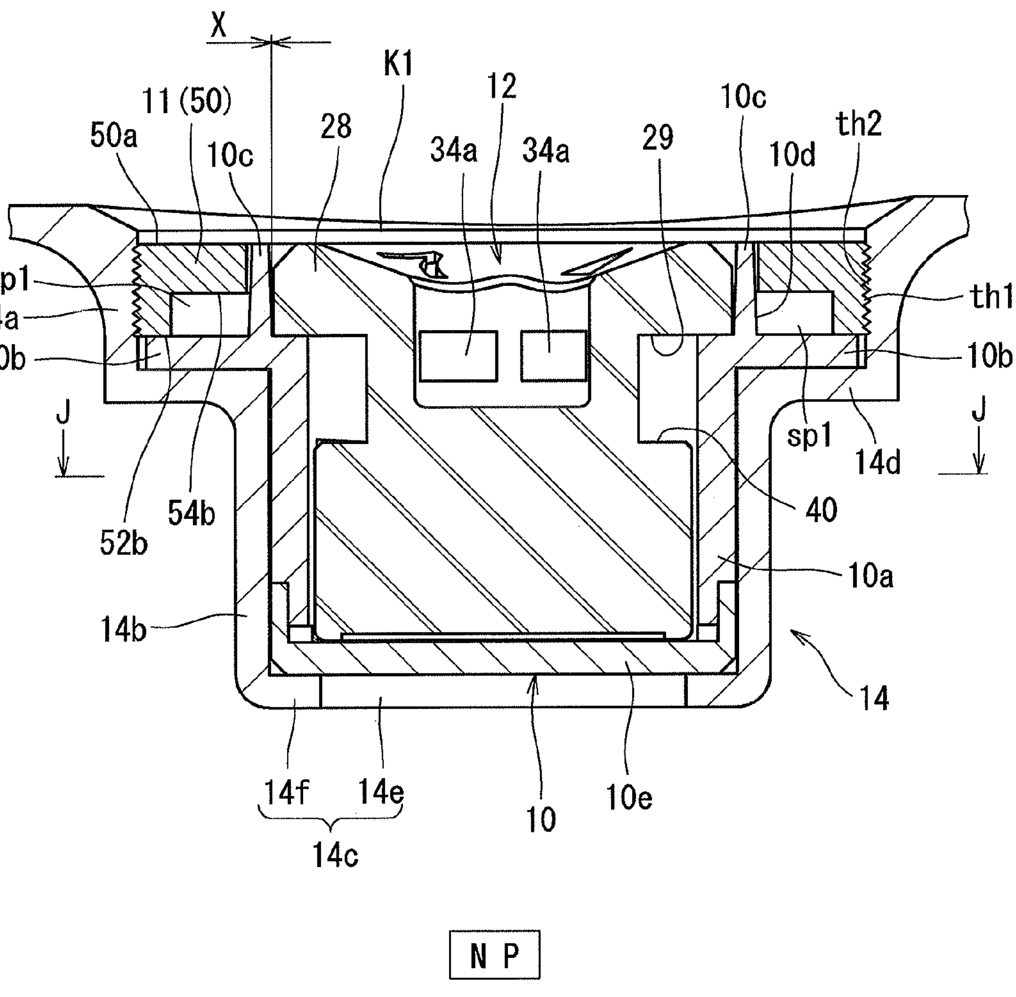
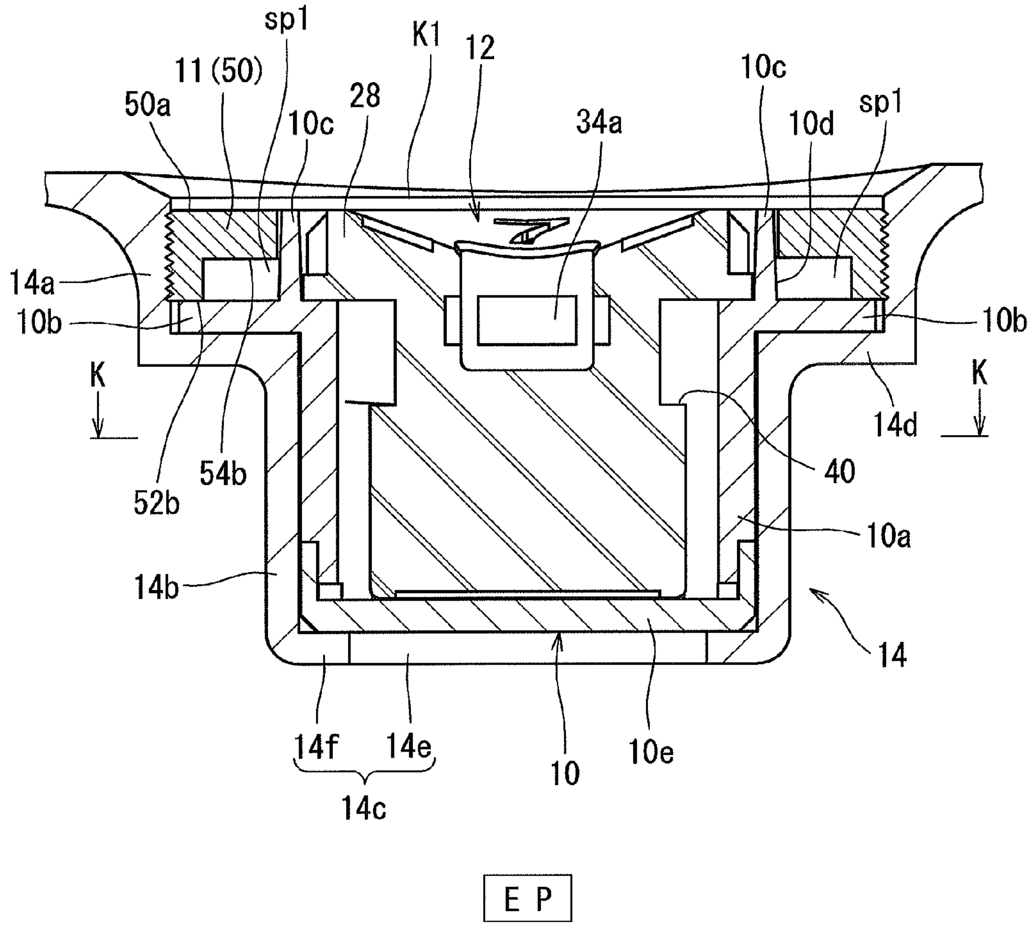

X
K1
12
11 (50)
50a
28
10c
34a
34a
29
10c
10d
th2
sp1
14a
10b
th1
10b
J
J
sp1
14d
52b
54b
40
10a
14b
14
14f
14e
14c
10
10e
N P

FIG. 18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K1
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11 (50)
50a
28
10c
34a
10c
10d
sp1
14a
10b
10b
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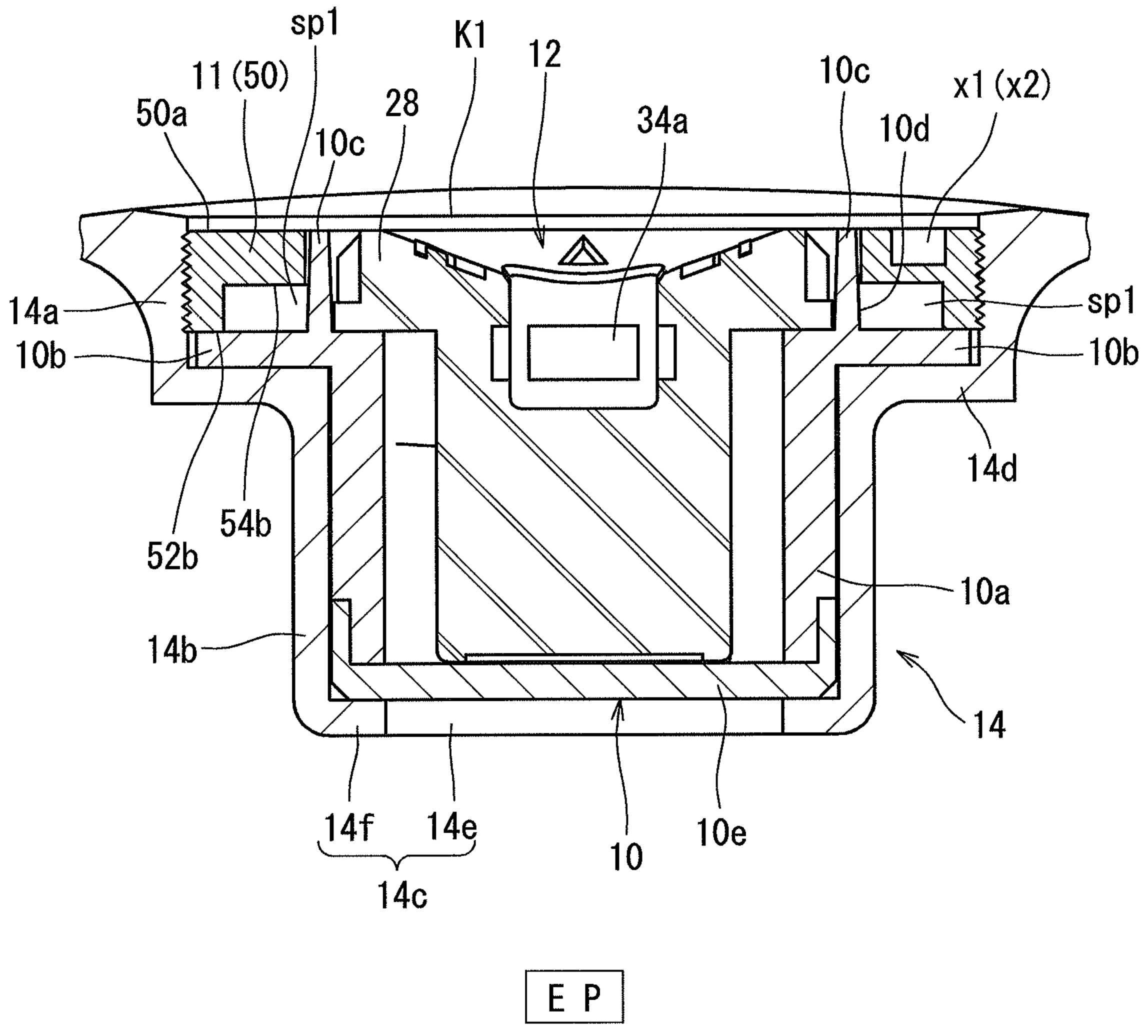
14c
10
10e
E P

FIG. 19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10c
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10d
14a
sp1
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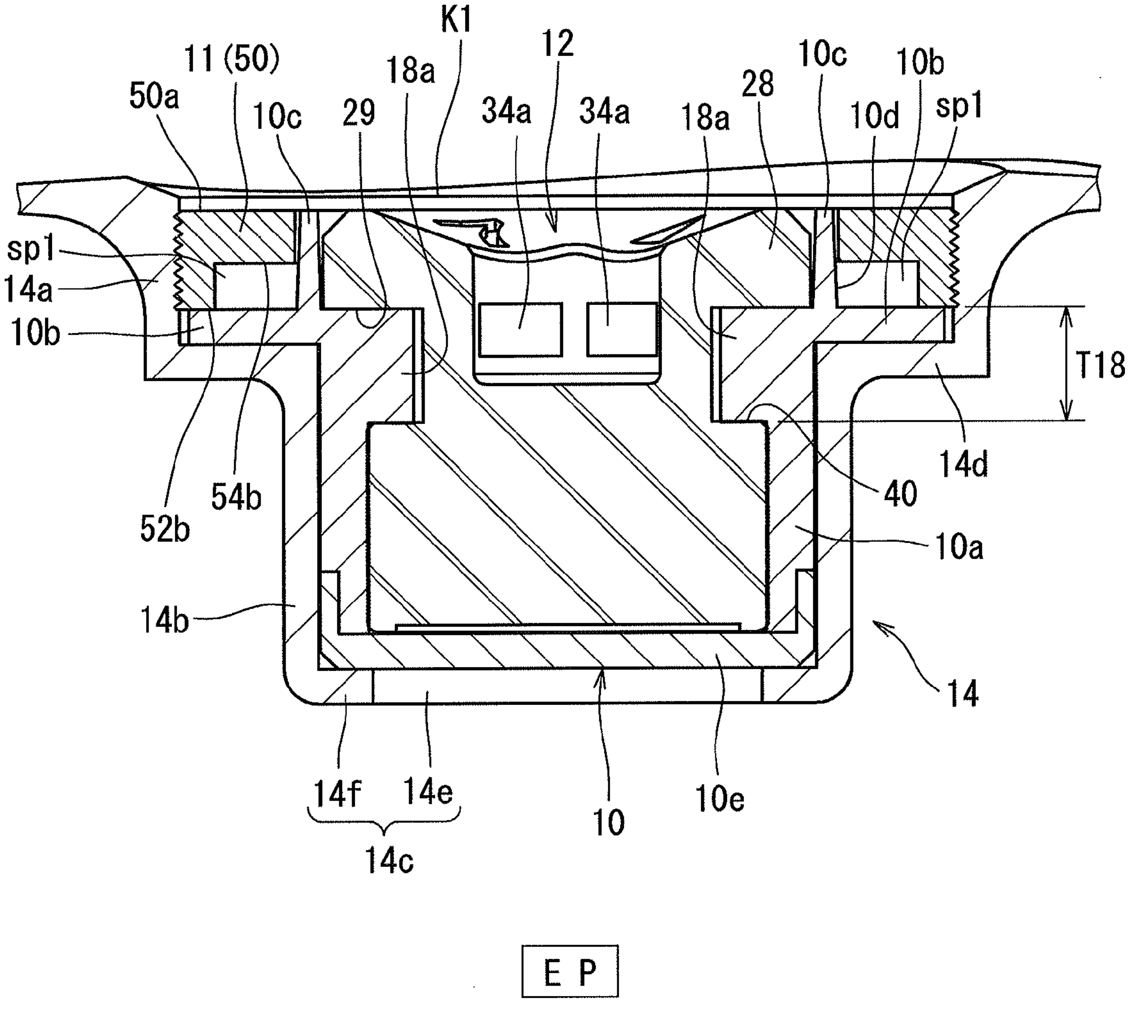
14d
54b
52b
10a
14b
14
14f
14e
10
10e
14c
E P

FIG. 20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11 (50)
18a
10c
10b
50a
10c
29
34a
34a
18a
28
10d
sp1
sp1
14a
10b
T18
14d
40
10a
52b
54b
14b
14
14f
14e
10
10e
14c
E P

FIG. 21

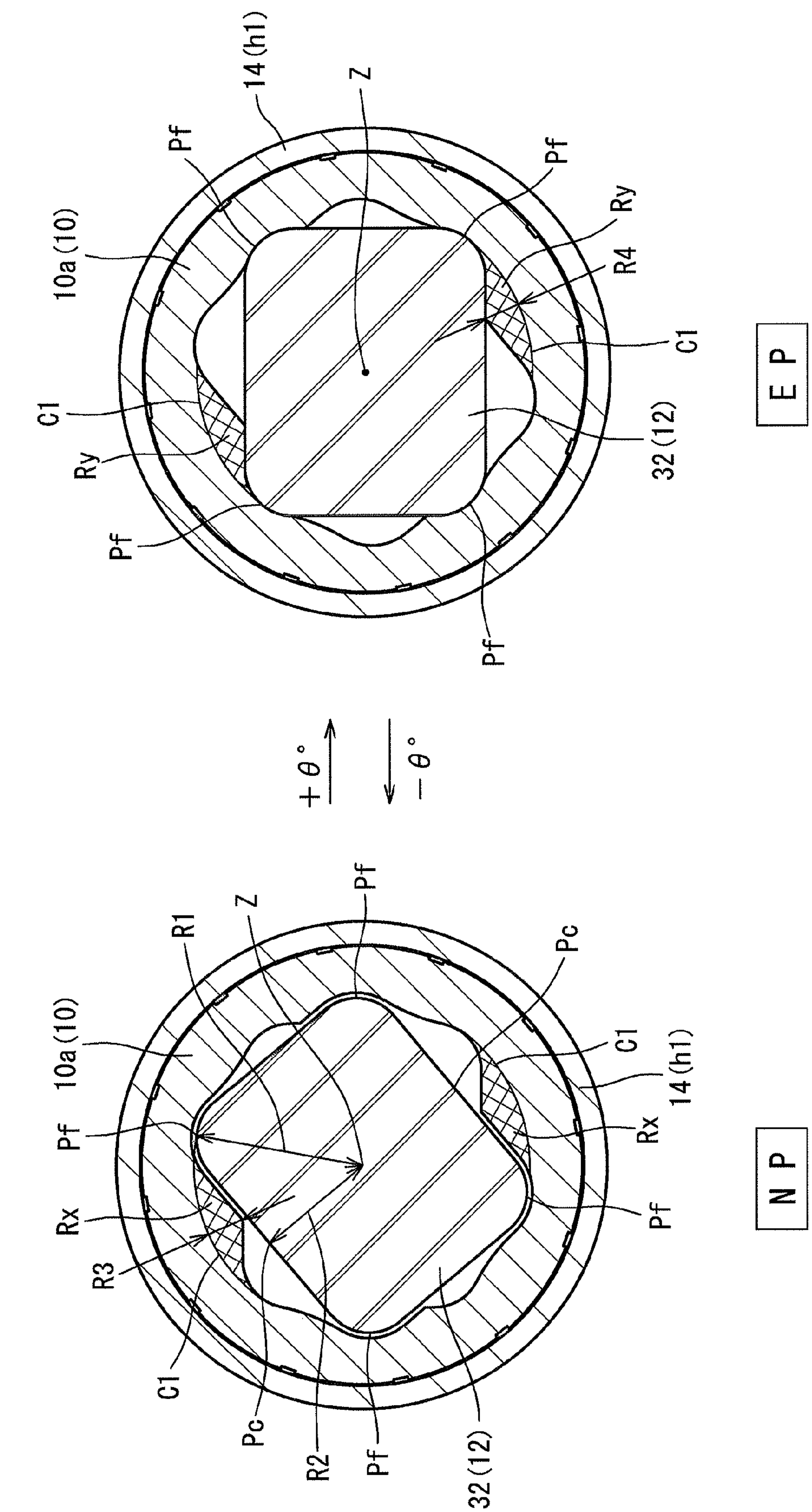


FIG. 22

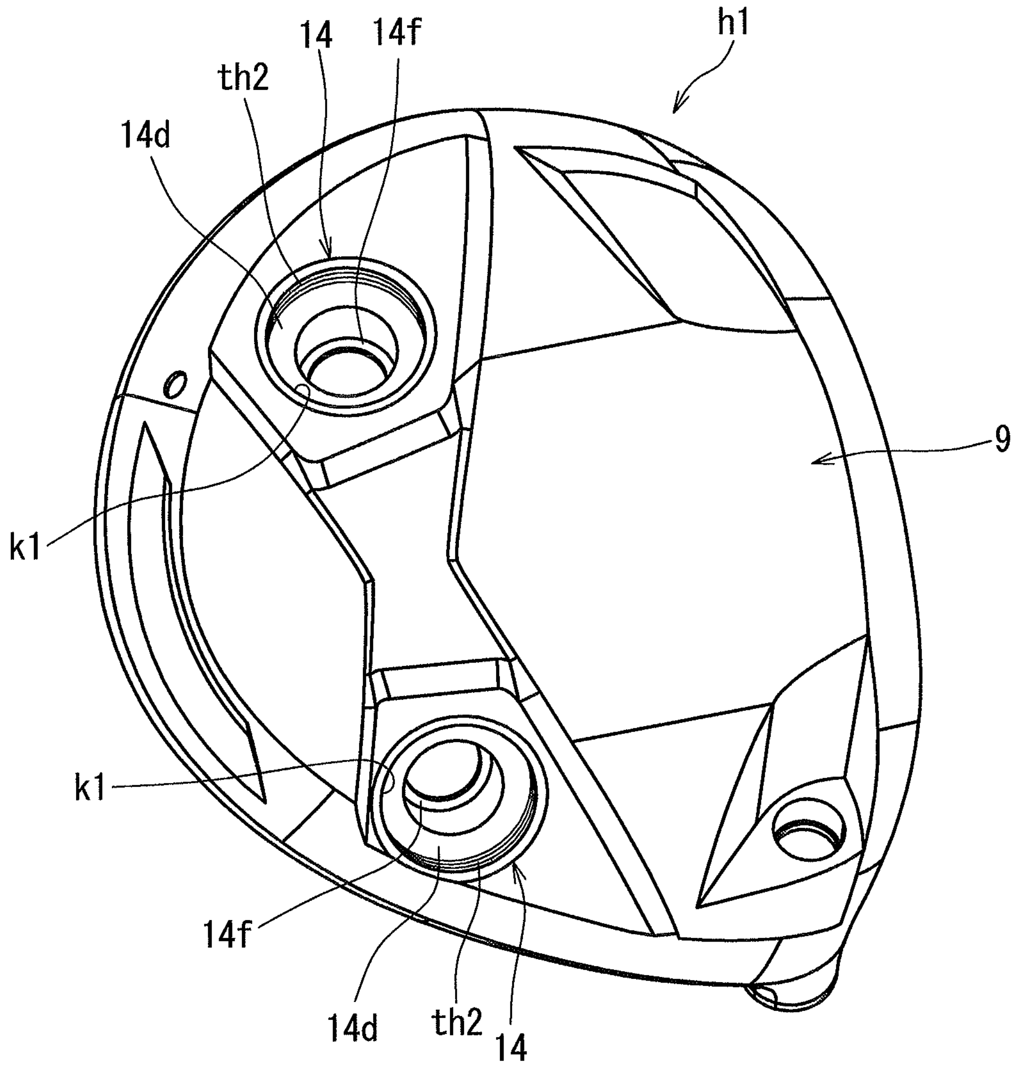


FIG. 23

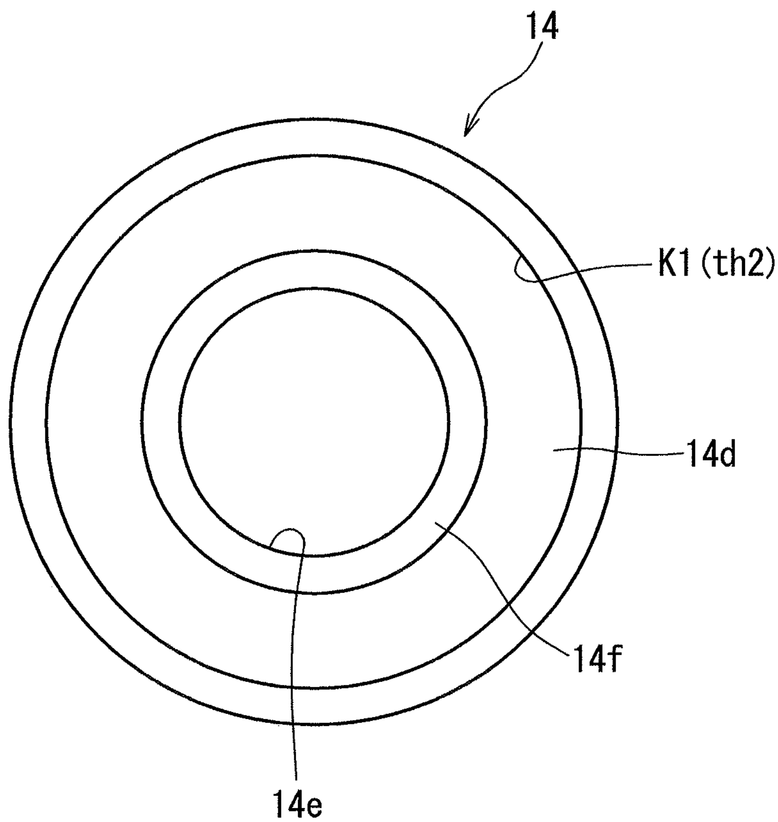


FIG. 24

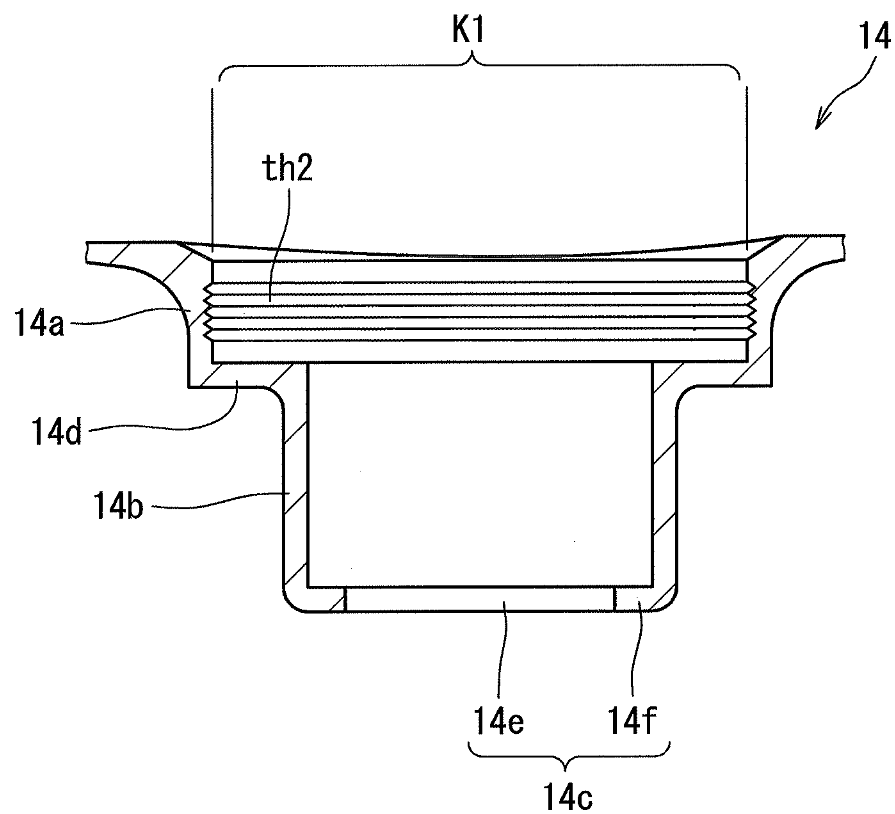
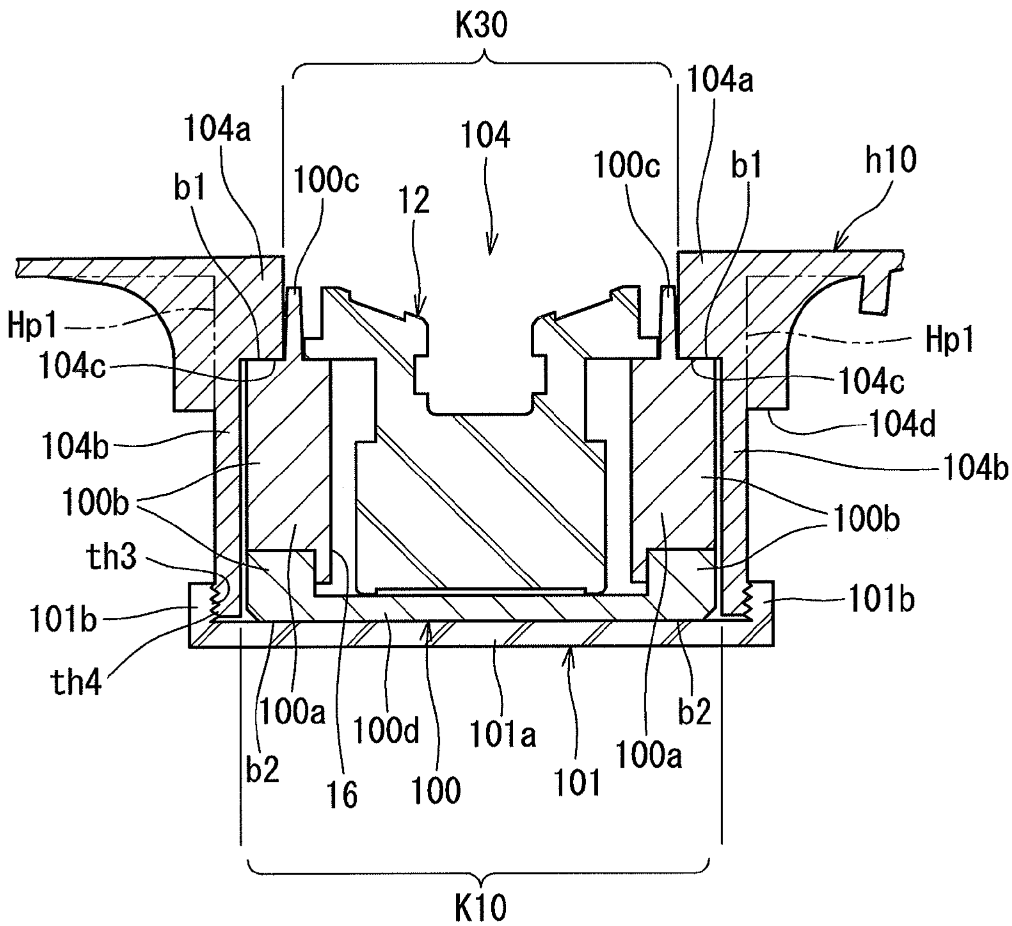


FIG. 25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Hp1
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104c
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104b
100b
100b
th3
101b
101b
th4
100a
100d
101a
b2
b2
16
100
101
100a
K10

FIG. 26

GOLF CLUB HEAD

The present application claims priority on Patent Application No. 2013-106724 filed in JAPAN on May 21, 2013, the entire contents of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a golf club head including a weight body.

2. Description of the Related Art

A head in which a weight body is replaceable is known. The position of the center of gravity of the head and the weight of the head can be adjusted by changing the weight of the weight body.

As a mechanism for attaching the weight body, a screw mechanism is typically used. Meanwhile, Japanese Utility Model Registration Publication No. 3142270 (US2009/0131200) discloses a mechanism including a sleeve and a weight. The sleeve is formed of a flexible material. Japanese Patent Application Laid-Open Publication No. 2012-139403 (US2012/0172142) discloses a head cavity body mounted on a head and a head weight attachable to and detachable from the head cavity body. The material of the head cavity body is a polymer. In these publications, the weight can be attached by rotating the weight at a predetermined angle, and the weight can be detached by rotating the weight oppositely at a predetermined angle.

SUMMARY OF THE INVENTION

Preferably, the weight body can be easily attached and easily detached. From the viewpoint of convenience, preferably, attaching and detaching work is easy.

On the other hand, it is necessary to maintain the fixed state of the weight body during play. In hitting a ball, a strong impact force is applied from the ball to the head. Moreover, the head can collide against the ground in impact. The weight body is apt to detach from the head. From the viewpoint of reliability, preferably, the weight body is fixed more securely.

It is an object of the present invention to provide a highly reliable golf club head, to and from which a weight body is attachable and detachable.

A head according to an embodiment of the present invention includes a head main body, an attachment member, a socket, and a weight body. The head main body includes a socket housing portion. The socket is attached to the socket housing portion. The socket housing portion includes a first opening through which the socket can be housed. The attachment member is mechanically joined to the head main body. The attachment member is disposed so as to block at least a part of the first opening. The attachment member controls falling off of the socket from the first opening. The socket includes a held portion. The held portion is pressed by the attachment member. The socket is formed of a polymer whose elastic modulus is lower than an elastic modulus of the head main body. The weight body is detachably attached to the socket.

The first opening may be opened to the outer side of the head. Preferably, the attachment member is a ring member. Preferably, the ring member is disposed so as to block a part of the first opening. Preferably, the ring member includes a second opening through which the weight body can be inserted into the socket.

Preferably, relative rotation is enabled between the weight body and the socket. Preferably, the relative rotation allows the weight body to be placed at an engaging position and a non-engaging position. Preferably, the ring member includes an indication. Preferably, the indication facilitates determination whether the weight body is at the engaging position or not.

Preferably, the socket further includes an intermediate portion. Preferably, the intermediate portion is positioned between the ring member and the weight body. Preferably, the ring member contacts at least a part of an outer side surface of the intermediate portion.

The first opening of the socket housing portion may be opened to an inner side of a head. In this case, preferably, the socket housing portion further includes a third opening opened to an outer side of the head. Preferably, the third opening allows the weight body to be inserted and controls falling off of the socket to the outer side of the head.

Preferably, the held portion is held between the attachment member and the head main body.

Preferably, a space is provided between the held portion and the attachment member.

Preferably, the socket further includes an intermediate portion. Preferably, the intermediate portion is positioned between the attachment member and the weight body. Preferably, the attachment member does not directly contact the weight body.

Preferably, the socket housing portion includes a bottom portion. Preferably, the bottom portion includes an inward extending portion and a through hole. Preferably, the inward extending portion supports a bottom face of the socket.

A specific gravity of the head main body is G**1**, a specific gravity of the attachment member is G**2**, and a specific gravity of the socket is G**3**. In this case, preferably, the specific gravity G**1** is greater than the specific gravity G**2**. Preferably, the specific gravity G**2** is greater than the specific gravity G**3**.

Preferably, the socket housing portion includes a side wall portion. Preferably, an outer diameter of the side wall portion is constant.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an overall view of a golf club including a head according to a first embodiment of the present invention;

FIG. **2** is a perspective view of the head in FIG. **1**, and includes an exploded perspective view of a weight body attaching/detaching mechanism;

FIG. **3** is a perspective view of a socket;

FIG. **4**A is a plan view of a socket and FIG. **4**B is a bottom view of the socket;

FIG. **5** is a side view of the socket;

FIG. **6** is a cross-sectional view taken along line A-A in FIG. **4**A;

FIG. **7** is a cross-sectional view taken along line B-B in FIG. **5**;

FIG. **8** is a perspective view of a weight body;

FIG. **9**A is a plan view of the weight body and FIG. **9**B is a bottom view of the weight body;

FIGS. **10**A and **10**B are side views of the weight body;

FIG. **11** is a cross-sectional view taken along line C-C in FIG. **10**A;

FIG. **12** is a cross-sectional view taken along line D-D in FIG. **11**;

FIG. **13** is a plan view of the weight body attaching/detaching mechanism attached to a socket housing portion, and is a view at a non-engaging position NP;

FIG. **14** is a plan view of the weight body attaching/detaching mechanism attached to the socket housing portion, and is a view at an engaging position EP;

FIG. **15**A is a perspective view of a ring member, FIG. **15**B is a bottom view of the ring member, and FIG. **15**C is a cross-sectional view of the ring member;

FIG. **16** is a perspective view of a tool for rotating the weight body;

FIG. **17** is a cross-sectional view of a second hole and an engaging portion, illustrating the non-engaging position NP and the engaging position EP;

FIG. **18** is a cross-sectional view taken along line E-E in FIG. **13**;

FIG. **19** is a cross-sectional view taken along line F-F in FIG. **14**;

FIG. **20** is a cross-sectional view taken along line G-G in FIG. **14**;

FIG. **21** is a cross-sectional view taken along line H-H in FIG. **14**;

FIG. **22** is cross-sectional views at the non-engaging position NP and the engaging position EP, in which the left side in FIG. **22** is a cross-sectional view taken along line J-J in FIG. **18**, and the right side in FIG. **22** is a cross-sectional view taken along line K-K in FIG. **19**;

FIG. **23** is a perspective view of a head main body;

FIG. **24** is a plan view of the socket housing portion;

FIG. **25** is a cross-sectional view of the socket housing portion; and

FIG. **26** is a cross-sectional view of a head according to an exemplary modification.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following, the present invention will be described in detail based on preferred embodiments with appropriate reference to the drawings. It is noted that for convenience, in the present application, the outer side of a head is also referred to as the upper side and the inner side of the head is also referred to as the lower side.

A golf club head according to an embodiment includes a weight body attaching/detaching mechanism. The mechanism satisfies the Golf Rules defined by R&A (Royal and Ancient Golf Club of Saint Andrews). That is, the weight body attaching/detaching mechanism satisfies requirements specified in "lb. Adjustability" in "1. Clubs" in "Appendix II. Design of Clubs" defined by R&A. The requirements defined by the "lb Adjustability" are the following items (i), (ii), and (iii):

(i) the adjustment cannot be readily made;
(ii) all adjustable parts are firmly fixed and there is no reasonable likelihood of them working loose during a round; and
(iii) all configurations of adjustment conform with the Rules.

FIG. **1** is a golf club **2** including a head **4** according to a first embodiment. The golf club **2** includes the head **4**, a shaft **6**, and a grip **8**. The head **4** is attached to one end portion of the shaft **6**. The grip **8** is attached to the other end portion of the shaft **6**. The head **4** includes a crown **7** and a sole **9**. The head **4** is hollow.

The head **4** is a wood type head. The real loft angle of the wood type head is usually 8 degrees or greater and 34 degrees or less. The head volume of the wood type head is usually 120 cc or greater and 470 cc or less.

The head **4** is an exemplary. The head **4** includes a wood type head, a utility type head, a hybrid type head, an iron type head, and a putter type head. The shaft **6** is a tubular body. The shaft **6** includes a steel shaft and a so-called carbon shaft.

FIG. **2** is a perspective view of the head **4** viewed from the sole **9** side. The head **4** includes a head main body h**1** and a weight body attaching/detaching mechanism M**1**. The head **4** includes a plurality of (two) weight body attaching/detaching mechanisms M**1**. FIG. **2** includes an exploded perspective view of the weight body attaching/detaching mechanism M**1**. One of the two weight body attaching/detaching mechanisms M**1** is illustrated in the exploded perspective view.

As illustrated in FIG. **2**, the weight body attaching/detaching mechanism M**1** includes a socket **10**, an attachment member **11**, and a weight body **12**. The head main body h**1** includes a socket housing portion **14**. The inner shape of the socket housing portion **14** corresponds to the outer shape of the socket **10**. The number of the socket housing portions **14** is the same as the number of the weight body attaching/detaching mechanism M**1**. The number of the socket housing portions **14** is the same as the number of the sockets **10**. In the embodiment, two socket housing portions **14** are provided. The number of the socket housing portions **14** may be one, two, or three or more than three. The number of the weight body attaching/detaching mechanism M**1** may be one, two, or three or more than three.

FIG. **3** is a perspective view of the socket **10**. FIG. **4**A is a plan view of the socket **10**. FIG. **4**B is a bottom view of the socket **10**. FIG. **5** is a side view of the socket **10**. FIG. **6** is a cross-sectional view taken along line A-A in FIG. **4**. FIG. **7** is a cross-sectional view taken along line B-B in FIG. **5**.

The socket **10** is fixed to the inner side of the socket housing portion **14**. The fixing is attained using an adhesive, for example. The socket **10** may not be fixed using an adhesive. The socket **10** may be fixed by being held between the attachment member **11** and the head main body h**1**. The socket **10** may be fixed only by being held between the attachment member **11** and the head main body h**1**.

The socket **10** includes a main body portion **10***a*, a held portion **10***b*, and an intermediate portion **10***c*. The main body portion **10***a* includes a hole **16**. The hole **16** extends through the main body portion **10***a*.

The held portion **10***b* is in a flange shape. The held portion **10***b* is in an annular shape. The held portion **10***b* extends from the main body portion **10***a* to the outer side in an axial perpendicular direction. The axial perpendicular direction means a direction perpendicular to a rotation axis line Z of the weight body **12**. The held portion **10***b* is positioned on the upper end portion of the main body portion **10***a*. The held portion **10***b* is positioned between the head main body h**1** and the attachment member **11**. The held portion **10***b* is positioned between the socket housing portion **14** and the attachment member **11**.

The intermediate portion **10***c* is in a tubular shape. The intermediate portion **10***c* extends in the axial direction. The axial direction means the direction of the axis line Z. The center axial line of the intermediate portion **10***c* is matched with the axis line Z. As illustrated in FIG. **6**, the intermediate portion **10***c* extends upwardly from the top end of the main body portion **10***a*. The top end of the intermediate portion **10***c* is a free end. The inner diameter of the intermediate portion **10***c* is set so as to pass the weight body **12** through the intermediate portion **10***c*. The weight body **12** can be inserted into the socket **10** through the intermediate portion **10***c*.

The intermediate portion **10***c* is provided throughout in the circumferential direction. The intermediate portion **10***c* may be intermittently provided in the circumferential direction. The effect, described later, can be exerted even when the intermittent intermediate portion **10***c* is provided.

The weight body **12** is detachably attached to the socket **10**. Therefore, the weight body **12** is detachably attached to the head **4**. The position of the center of gravity of the head can be changed by replacing the weight body **12**. The weight of the head can be changed by replacing the weight body **12**.

As illustrated in FIG. **6**, the hole **16** includes a first hole portion **18**, a second hole portion **20**, and a step surface **22**. The second hole portion **20** is positioned on the deeper side (the lower side) of the first hole portion **18**. The entire inner surface of the first hole portion **18** smoothly continues. In the embodiment, the cross-sectional shape of the inner surface of the first hole portion **18** is in a substantially rectangular shape (see FIGS. **4**A and **4**B). The substantially rectangular shape is a rectangular shape with four rounded corners. The cross-sectional shape of the inner surface of the first hole portion **18** is substantially the same as the cross-sectional shape of an engaging portion **32** of the weight body **12**.

As illustrated in FIG. **7**, the cross-sectional shape of the inner surface of the second hole portion **20** includes complicated unevenness. The detail of the cross-sectional shape will be described later.

The cross-sectional shape of the first hole portion **18** is different from the cross-sectional shape of the second hole portion **20**. The step surface **22** is formed due to the difference (see FIG. **4**B). The step surface **22** is a downward surface.

As illustrated in FIG. **2**, the socket **10** includes a bottom face forming part **10***e*. The bottom face forming part **10***e* forms the bottom part of the socket **10**. The bottom face forming part **10***e* blocks the lower opening of the second hole portion **20**. The bottom face forming part **10***e* can prevent the weight body **12** from contacting the bottom portion of the socket housing portion **14**. It is noted that the bottom face forming part **10***e* may not be included. The bottom face forming part **10***e* may be integrally formed with the other parts of the socket **10**.

The socket **10** is formed of a polymer. An elastic modulus Es of the polymer is lower than an elastic modulus Eh of a material forming the head main body h**1**. Preferably, the material of the socket **10** is a resin. The second hole portion **20** of the socket **10** can be elastically deformed in association with rotation of the weight body **12**. The detail of the elastic deformation will be described later.

FIG. **8** is a perspective view of the weight body **12**. FIG. **9**A is a plan view of the weight body **12**. FIG. **9**B is a bottom view of the weight body **12**. FIGS. **10**A and **10**B are side views of the weight body **12**. The view point is different between FIG. **10**A and FIG. **10**B at an angle of 90°. FIG. **11** is a cross-sectional view taken along line C-C in FIG. **10**A. FIG. **12** is a cross-sectional view taken along line D-D in FIG. **11**.

As illustrated in FIGS. **8**, **10**A, and **10**B, the weight body **12** includes a head portion **28**, a neck portion **30**, and the engaging portion **32**. A noncircular hole **34** is formed at the center of the upper end face of the head portion **28**. In the embodiment, the shape of the noncircular hole **34** is in a substantially quadrilateral shape. A recess **34***a* is provided on the inner surface of the noncircular hole **34** (see FIG. **11**). A plurality of cutouts **36** is formed on the outer circumferential surface of the head portion **28**. The outer surface of the neck portion **30** is a circumferential surface. The neck portion **30** is in a cylindrical shape. The top surface of the head portion **28** is externally exposed as fixed to the socket **10**.

The outer surface of the engaging portion **32** has a noncircular cross-sectional shape S**32**. As illustrated in FIGS. **9**B and **12**, in the embodiment, the cross-sectional shape S**32** is in a substantially rectangular shape. The cross-sectional shape S**32** of the engaging portion **32** and a cross-sectional shape S**18** of the first hole portion **18** are in the similar relationship (see FIG. **4**B). The cross-sectional shape S**32** of the engaging portion **32** is (slightly) smaller than the sectional shape S**18**. The engaging portion **32** can be inserted into the first hole portion **18**.

As illustrated in FIG. **11**, a recess **38** is formed on the lower end face of the engaging portion **32**. The volume of the weight body **12** can be adjusted by the volume of a space formed by the recess **38** without changing the outer shape of a portion engaged with the socket **10**. Therefore, the mass of the weight body **12** can be easily adjusted.

As illustrated in FIG. **9**B, the engaging portion **32** includes a corner **32***a*. A plurality of corners **32***a* is provided. In the embodiment, four corners **32***a* are provided. The corner **32***a* forms a protruding portion that protrudes in the axial perpendicular direction.

The engaging portion **32** includes an engaging surface **40** (see FIGS. **8**, **10**A, and **12**). The engaging surface **40** is formed due to the difference between the cross-sectional shapes of the engaging portion **32** and the neck portion **30**. The engaging surface **40** is an upward surface. The engaging surface **40** is opposed to a lower surface **29** of the head portion **28**.

A specific gravity G**4** of the weight body **12** is greater than a specific gravity G**1** of the head main body h**1**. The specific gravity G**4** of the weight body **12** is greater than a specific gravity G**3** of the socket **10**. From the viewpoint of durability and specific gravity, preferably, the material of the weight body **12** is a metal. The metal includes aluminum, an aluminum alloy, titanium, a titanium alloy, stainless steel, a tungsten alloy, and a tungsten nickel alloy (W—Ni alloy). An example of the titanium alloy is a 6-4Ti (Ti-6Al-4V) alloy. An example of stainless steel is *SUS*304 steel.

A method of manufacture of the weight body **12** is forging, casting, sintering, and NC processing, for, example. Preferably, in the case of an aluminium alloy, a 6-4Ti alloy, and SUS304 steel, NC processing is preferably performed after casting. NC stands for "Numerical Control".

FIG. **13** is a plan view of the weight body attaching/detaching mechanism M**1** at a non-engaging position NP. FIG. **14** is a plan view of the weight body attaching/detaching mechanism M**1** at an engaging position EP.

The weight body **12** can be rotated with respect to the socket **10**. With the relative rotation, the weight body **12** can be placed at the non-engaging position NP and the engaging position EP.

At the non-engaging position NP, the weight body **12** can be pulled out of the socket **10**. At the non-engaging position NP, the weight body **12** is in an unlocked state.

In contrast to this, at the engaging position EP, the weight body **12** cannot be pulled out of the socket **10**. At the engaging position EP, the weight body **12** is fixed to the socket **10**. At the engaging position EP, the weight body **12** is in a locked state. When the club **2** is being used, the weight body **12** is set at the engaging position EP. The weight body **12** in the locked state does not fall off.

At the time point at which the weight body **12** is inserted into the socket **10**, the weight body **12** is at the non-engaging position NP with respect to the socket **10**. By the relative rotation at an angle of θ, the position of the weight body **12** is changed from the non-engaging position NP to the engaging position EP. By the reverse relative rotation at the angle of θ, the position of the weight body **12** is returned from the engaging position EP to the non-engaging position NP. An angle of the relative rotation changed from the non-engaging position NP to the engaging position EP is also noted as "++θ" in the present application. An angle of the relative rotation changed from the engaging position EP to the non-engaging position NP is noted as "−θ" in the present application. The reference signs "+" and "−" are noted in order to express that the rotation directions are opposite to each other.

In the weight body attaching/detaching mechanism **M1**, the weight body **12** can be attached and detached only by rotating the weight body **12** at the angle of θ. The weight body attaching/detaching mechanism **M1** is excellent in the ease of attachment and detachment.

In the embodiment, the angle of θ is 40°. The angle of θ is not limited to 40°. From the viewpoint of reliability of fixing, the angle of θ is preferably equal to or greater than a 20°, and more preferably equal to or greater than 30°. From the viewpoint of the ease of attachment and detachment, the angle of θ is preferably equal to or less than 60°, and more preferably equal to or less than 50°.

FIG. **15**A is a perspective view of the attachment member **11**. FIG. **15**B is a bottom view of the attachment member **11**. FIG. **15**C is a cross-sectional view of the attachment member **11**. It is noted that FIGS. **13** and **14** include a plan view of the attachment member **11**.

In the embodiment, the attachment member **11** is a ring member **50**. The ring member **50** includes an opening K**2**. In order to distinguish from the other openings, the opening K**2** is also referred to as a second opening. The second opening K**2** extends through the ring member **50**. The weight body **12** can be inserted into the socket **10** through the second opening K**2**. The inner diameter of the ring member **50** is set in such a way that the weight body **12** can be inserted into the socket **10** through the second opening K**2**.

As illustrated in FIG. **15**B, the ring member **50** includes an outer circumferential portion **52** and an inner circumferential portion **54**. As illustrated in FIG. **15**C, a thickness t**1** of the outer circumferential portion **52** is greater than a thickness t**2** of the inner circumferential portion **54**.

As illustrated in FIG. **15**C, a top surface **52***a* of the outer circumferential portion **52** is flush with a top surface **54***a* of the inner circumferential portion **54**. The top surface **50***a* of the ring member **50** is formed of the top surface **52***a* and the top surface **54***a*. On the other hand, a lower surface **52***b* of the outer circumferential portion **52** is not flush with a lower surface **54***b* of the inner circumferential portion **54**. The lower surface **54***b* is positioned on the upper side of the lower surface **52***b*.

As illustrated in FIG. **15**A, the ring member **50** includes an indication x**1**. The indication x**1** is provided on the top surface **50***a* of the ring member **50**. In the state in which the ring member **50** is attached to the head **4**, the indication x**1** can be visually recognized. The ring member **50** includes a plurality of indications x**1** (in the embodiment, three indications x**1**). The indications x**1** are disposed in the circumferential direction of the ring member **50** at regular intervals.

In the embodiment, the indication x**1** is a recess. Thus, the indication x**1** may be three-dimensionally formed. A three-dimensional indication x**1** includes a recess and a projection. The indication x**1** may not be in a three-dimensional shape. For example, the indication x**1** can be formed by making the color different from the colors of the surrounding portions by coating, for example. It is fine that the indication x**1** is visually recognized.

The indication x**1** is useful to determine the position of the weight body **12**. As understood from the comparison between FIG. **13** and FIG. **14**, the indication x**1** facilitates the determination whether the weight body **12** is at the engaging position EP.

As illustrated in FIG. **15**A, the ring member **50** includes a rotation engaging portion x**2**. The engaging portion x**2** is provided on the top surface **50***a* of the ring member **50**. In the state in which the ring member **50** is attached to the head **4**, the engaging portion x**2** is exposed. A tool for rotating the ring member **50** can be engaged with the engaging portion x**2**. The engaging portion x**2** makes the rotation of the ring member **50** easy when the ring member **50** is screwed. In the embodiment, the engaging portion x**2** also serves as the indication x**1**.

The ring member **50** includes a plurality of engaging portions x**2** (in the embodiment, three engaging portions). The engaging portions x**2** make the rotation of the ring member **50** easy. The engaging portions x**2** are disposed at regular intervals in the circumferential direction of the ring member **50**. Thus, the torque for rotating the ring member **50** can be uniformly applied in the circumferential direction.

In the embodiment, the engaging portion x**2** is a recess. The recess may be a groove. The recess attains a reduction in the weight of the ring member **50**. It is noted that the engaging portion x**2** is not limited to a recess. The engaging portion x**2** may be a projection, for example.

The weight body **12** includes an indication y**1** . As illustrated in FIGS. **13** and **14**, in the embodiment, a plurality of (four) indications y**1** is provided. In the embodiment, the indication y**1** is a numerical character and a mark. The positional relationship between the indication y**1** and the indication x**1** further facilitates the determination whether the weight body **12** is at the engaging position EP.

The indication y**1** includes a numerical character expressing the mass of the weight body **12**. In the embodiment, the indication y**1** includes the numerical character, "7". The weight body **12** has seven grams.

As illustrated in FIG. **8**, in the embodiment, the indication y**1** is a recess. Thus, the indication y**1** may be three-dimensionally formed. A three-dimensional indication y**1** includes a recess and a projection. Moreover, the indication y**1** may not be in a three-dimensional shape. For example, the indication y**1** can be formed by making the color different from the colors of the surrounding portions by coating, for example. It is fine that the indication y**1** is visually recognized.

A screw thread th**1** is formed on the ring member **50**. The screw thread th **1** is formed on the outer circumferential surface of the ring member **50**. The screw thread th**1** is a male thread.

A dedicated tool may be used for rotating the weight body **12**. FIG. **16** is a perspective view of an example of a tool **60**. The tool **60** includes a handle **62**, a shaft **64**, and a tip end portion **66**. The handle **62** includes a handle body **68** and a holding part **70**. The holding part **70** includes a holding part main body **70***a* and a lid **70***b*.

The rear end portion of the shaft **64** is fixed to the holding part main body **70***a*. The cross-sectional shape of the tip end portion **66** of the shaft **64** corresponds to the cross-sectional shape of the noncircular hole **34** of the weight body **12**. In the embodiment, the cross-sectional shape of the tip end portion **66** is in a quadrilateral shape. A pin **72** is provided at the tip end portion **66**. The pin **72** protrudes on the side surface of the tip end portion **66**. Although not illustrated, an elastic body (a coil spring) is built in the tip end portion **66**. The pin **72** is biased in the protruding direction by the biasing force of the elastic body.

When the weight body **12** is attached and detached, the lid **70***b* is closed. A weight body housing portion (not illustrated) is provided in the holding part main body **70***a*. Preferably, the weight body housing portion can house a plurality of weight bodies **12**. Preferably, the weight bodies **12** with different weights are housed. The weight bodies **12** can be taken out by opening the lid **70***b*.

When the weight body **12** is attached, the tip end portion **66** of the tool **60** is inserted into the noncircular hole **34** of the weight body **12**. The pin **72** presses the noncircular hole **34** while going backward according to the insertion. The weight body **12** is less likely to fall off from the tip end portion **66** due to the pressing force. The pin **72** can enter the recess **34***a* of the noncircular hole **34** (see FIG. **11**). The weight body **12** is less likely to fall off from the tip end part **66** due to the entering of the pin **72**. The weight body **12** held on the shaft **64** of the tool **60** is inserted into the hole **16**.

The weight body **12** is inserted into the inner side of the attachment member **11** (the ring member **50**), and reaches the socket **10**. The weight body **12** is inserted into the inner side of the intermediate portion **10***c*, and reaches the hole **16**.

The engaging portion **32** of the weight body **12** passes through the first hole portion **18** of the hole **16**, and reaches the second hole portion **20**. Immediately after the insertion, the weight body **12** is at the non-engaging position NP.

The weight body **12** at the non-engaging position NP is relatively rotated at an angle of +θ°. More specifically, the weight body **12** is rotated at an angle of +θ° with respect to the socket **10** using the tool **60**. By the rotation, the position of the weight body **12** is changed from the non-engaging position NP to the engaging position EP. In this manner, the weight body **12** is completely attached. The weight body **12** is easily attached.

When the weight body **12** is detached, the weight body **12** is reversely rotated at the angle of θ°. That is, the weight body **12** is rotated at an angle of −θ°. By the rotation, the position of the weight body **12** is changed from the engaging position EP to the non-engaging position NP. The weight body **12** at the non-engaging position NP can be pulled out. As described above, the pin **72** can enter the recess **34***a* of the noncircular hole **34** (see FIG. **11**). Due to the entering of the pin **72**, the weight body **12** can be pulled out more easily.

At the engaging position EP, it is not possible to pull the weight body **12** out of the hole **16**. At the engaging position EP, the engagement between the step surface **22** of the hole **16** and the engaging surface **40** of the weight body **12** inhibits the pulling out of the weight body **12**. At the engaging position EP, the tool **60** can be easily pulled out of the noncircular hole **34** of the weight body **12**.

FIG. **17** is cross-sectional views of the engaging portion **32** and the socket **10**. A cross-sectional view at the non-engaging position NP is illustrated on the left side in FIG. **17**. A cross-sectional view at the engaging position EP is illustrated on the right side in FIG. **17**. The axis line Z, which is the center axis of rotation at the angle of θ°, is illustrated by a point in FIG. **17**. The center of the cross section of the outline of the engaging portion **32** in the drawing is located on the axis line Z. The rotation of the weight body **12** in the relative rotation is rotation about the axis line Z.

As illustrated in FIG. **17**, the second hole portion **20** of the socket **10** includes anon-engaging corresponding surface **80**, an engaging corresponding surface **82**, and a resistance surface **84**. The non-engaging corresponding surface **80** is a surface corresponding to the engaging portion **32** at the non-engaging position NP. The engaging corresponding surface **82** is a surface corresponding to the engaging portion **32** at the engaging position EP. The resistance surface **84** is positioned between the non-engaging corresponding surface **80** and the engaging corresponding surface **82**.

During the mutual transition between the non-engaging position NP and the engaging position EP, the resistance surface **84** is pressed by the engaging portion **32**. The press is mainly made by the corner **32***a*. The press causes frictional force between the engaging portion **32** and the second hole portion **20**. The press elastically deforms the resistance surface **84**. The frictional force is changed based on the elastic modulus Es of the socket **10**. The frictional force causes rotational resistance. A great frictional force causes a great rotational resistance. The elastic modulus Es is increased, so that the rotational resistance can be increased. Because of a great rotational resistance, a strong torque is necessary for the mutual transition between the non-engaging position NP and the engaging position EP. In this case, the mutual transition does not easily take place. The transition from the engaging position EP to the non-engaging position NP is not caused by the impact force when hitting a ball. The tool **60** is necessary to the mutual transition. It is not possible to attain the mutual transition with hands with no use of the tool **60**. The weight body **12** at the engaging position EP does not fall off even by a strong impact when hitting a ball.

In the case where the elastic modulus Es is too large, an excessive torque is sometimes necessary to attain the mutual transition. From the viewpoint of the ease of attachment, an excessive torque is not preferable. The elastic modulus Es is set in such a way that the torque necessary to the mutual transition becomes appropriate.

In the mutual transition, the torque necessary to rotate the weight body **12** becomes the maximum when the resistance surface **84** is elastically deformed. The torque necessary to rotate the weight body **12** becomes the maximum during the mutual transition. Thus, the transition from the engaging position EP to the non-engaging position NP does not easily take place. The local maximum torque contributes to the prevention of falling off the weight body **12** during play.

As illustrated in FIG. **17**, the resistance surface **84** includes a projecting portion. The projecting portion is formed of a smooth curved surface. The projecting portion increases the rotational resistance caused during the mutual transition. The projecting portion can effectively suppress the release from the engaging position EP.

Thus, in the weight body attaching/detaching mechanism **M1**, the weight body **12** can be attached only by the relative rotation at the angle of θ. Moreover, the weight body **12** can be detached only by the relative rotation at the angle of θ.

At the non-engaging position NP, the engaging portion **32** does not deform the second hole portion **20**. As illustrated in the left view in FIG. **17**, at the non-engaging position NP, a gap can exist between the engaging portion **32** and the second hole portion **20**. Thus, at the non-engaging position NP, the weight body **12** is easily inserted and pulled out. On the other hand, as illustrated in the right view in FIG. **17**, at the engaging position EP, all the corners **32***a* are in intimate contact with the second hole portion **20** with no gap. In other words, at least a part of the corner **32***a* is a contact portion in all the corners **32***a*. The contact portion is a portion in intimate contact with the second hole portion **20** at the engaging position EP. As described above, the engaging portion **32** includes a plurality of contact portions. At the engaging position EP, the second hole portion **20** is expanded by the contact portions. The engaging corresponding surface **82** is pressed by the corner **32***a*, and the second hole portion **20** is elastically deformed by the press. The engaging corresponding surface **82** is elastically deformed. The elastic deformation expands the second hole portion **20**. The elastic deformation increases the distance between two engaging corresponding surfaces **82** opposite to each other. The dimensions of the engaging portion **32** and the dimensions of the second hole portion **20** are determined so as to allow the expansion. The weight body **12** is fixed by the restoring force of the elastic deformation.

As described above, in the weight body attaching/detaching mechanism **M1**, Configuration A and Configuration B below are attained. Configuration A further reliably provides the fixing of the weight body **12**. Moreover, Configuration B facilitates attaching and detaching work.

[Configuration A] At the engaging position EP, the engaging portion **32** elastically deforms the socket **10**, and the second hole portion **20** is expanded by the elastic deformation.

[Configuration B] At the non-engaging position NP, the engaging portion **32** does not elastically deform the socket **10**.

FIG. **18** is a cross-sectional view taken along line E-E in FIG. **13**. FIG. **18** is a cross-sectional view at the non-engaging position NP. FIG. **19** is a cross-sectional view taken along line F-F in FIG. **14**. FIG. **19** is a cross-sectional view at the engaging position EP. FIG. **20** is a cross-sectional view taken along line G-G in FIG. **14**. FIG. **20** is a cross-sectional view at the engaging position EP. FIG. **21** is a cross-sectional view taken along line H-H in FIG. **14**. FIG. **21** is a cross-sectional view at the engaging position EP.

FIG. **22** is a cross-sectional view of the mutual transition between the engaging position EP and the non-engaging position NP. A left side in FIG. **22** is a cross-sectional view taken along line J-J in FIG. **18**, and is a cross-sectional view at the non-engaging position NP. A right side in FIG. **22** is a cross-sectional view taken along line K-K in FIG. **19**, and is a cross-sectional view at the engaging position EP.

As described above, the socket **10** includes the first hole portion **18** and the second hole portion **20**. The cross-sectional shape of the first hole portion **18** is different from the cross-sectional shape of the second hole portion **20**. The difference in the cross-sectional shape causes the step surface **22**.

As illustrated in FIG. **21**, the first hole portion **18** includes an inner protruding portion **18*a***. The lower surface of the inner protruding portion **18*a*** is the step surface **22**.

At the non-engaging position NP, the inner protruding portion **18*a*** is not engaged with the weight body **12**. On the other hand, at the engaging position EP, the inner protruding portion **18*a*** is engaged with the weight body **12**. As illustrated in FIG. **21**, at the engaging position EP, the inner protruding portion **18*a*** is held between the lower surface **29** and the engaging surface **40**. Thus, the fixing of the weight body **12** is reliably attained.

In FIG. **21**, a two-directional arrow T**18** expresses the thickness of the inner protruding portion **18*a*** in the axial direction. As illustrated in FIG. **6**, the step surface **22** is sloped. Because of the slope, the axial-directional thickness T**18** is changed. As the weight body **12** is more rotated to the engaging position EP, the axial-directional thickness T**18** of a portion engaged with the weight body **12** is more increased. At the engaging position EP, the inner protruding part **18*a*** is compressively deformed so as to decrease the thickness T**18**. The pressing force is applied from the inner protruding portion **18*a*** to the lower surface **29** and the engaging surface **40** by the restoring force of the compressive deformation. For this reason, the fixing of the weight body **12** is further reliably attained.

The axial-directional thickness T**18** is gradually changed. Thus, the mutual transition between the engaging position EP and the non-engaging position NP can be smoothly performed.

As described above, in the weight body attaching/detaching mechanism M**1**, Configuration C, Configuration D, and Configuration F below are attained. With Configuration C, the fixing of the weight body **12** is further reliably attained. Moreover, Configuration D and Configuration E facilitate attaching and detaching work.

[Configuration C] At the engaging position EP, the weight body **12** holds the inner protruding portion **18*a*** of the socket **10**, and compressively deforms the inner protruding portion **18*a***.

[Configuration D] In the process in which the weight body **12** goes from the non-engaging position NP to the engaging position EP, the amount of the compressive deformation of the inner protruding portion **18*a*** is more increased as the weight body **12** comes closer to the engaging position EP.

[Configuration E] At the non-engaging position NP, the compressive deformation of the inner protruding portion **18*a*** is not caused.

A crosshatched portion on the left side in FIG. **22** (at the non-engaging position NP) expresses a reverse rotation suppressing portion Rx. A circular arc C**1** defining the reverse rotation suppressing portion Rx is a part of a circle in which the axis line Z is the center point and a distance from the center point Z to a point Pf is a radius R**1**. The point Pf is a point the farthest from the point Z on the outline of the cross section of the engaging portion **32**. The reverse rotation suppressing portion Rx can prevent reverse rotation in locking. The reverse rotation suppressing portion Rx promotes correct rotation to the engaging position EP (rotation of an angle of +θ°. That is, the effect of promoting normal rotation is exerted.

A crosshatched portion on the right side in FIG. **22** (at the engaging position EP) expresses an excess rotation suppressing portion Ry. The circular arc C**1** defining the excess rotation suppressing portion Ry is as described above. The excess rotation suppressing portion Ry can prevent excess rotation in locking. The excess rotation suppressing portion Ry prevents the engaging portion **32** at the engaging position EP from excessively rotating beyond the engaging position EP, and promotes the attainment of the engaging position EP. That is, the effect of suppressing excess rotation is exerted.

In the embodiment, the reverse rotation suppressing portion Rx and the excess rotation suppressing portion Ry are large, as described later. Thus, the effect of promoting normal rotation and the effect of suppressing excess rotation are high. In the embodiment, the projection forming the excess rotation suppressing portion Ry is also the reverse rotation suppressing portion Rx. When the weight body **12** is at the engaging position EP, the excess rotation suppressing portion Ry is compressed by the engaging portion **32**, and slightly deformed. On the other hand, when the weight body **12** is at the non-engaging position NP, the reverse rotation suppressing portion Rx is not compressively deformed. It is noted that the projection forming the excess rotation suppressing portion Ry and the projection forming the reverse rotation suppressing portion Rx may be provided separately.

FIG. **23** is a perspective view of the head main body h**1**. As described above, the head main body h**1** includes two socket housing portions **14**. The socket housing portion **14** may be a recess or a hole.

From the viewpoint of strength and durability, preferably, the material of the socket housing portion **14** is a metal. In the embodiment, the socket housing portion **14** is integrally formed with the other portions of the head main body h**1**. The socket housing portion **14** may be separately formed from the other portions of the head main body h**1**. In this case, preferably, the socket housing portion **14** is fixed to the head main body h**1** by welding.

FIG. **24** is a plan view of the socket housing portion **14**. FIG. **25** is a cross-sectional view of the socket housing portion **14**. The socket housing portion **14** can house at least a part of the socket **10**. In the embodiment, the socket housing portion **14** houses the socket **10** entirely.

The socket housing portion **14** includes a first side wall portion **14*a***, a second side wall portion **14*b***, a bottom portion **14*c***, and a step portion **14*d***. The first side wall portion **14*a*** and the second side wall portion **14*b*** are the side wall portions of the socket housing portion **14**. The bottom portion **14***c* includes a through hole **14***e* and an inward extending portion **14***f*. The inner circumferential surface of the first side wall portion **14***a* is coaxial with the inner circumferential surface of the second side wall portion **14***b*. The inner diameter of the first side wall portion **14***a* is greater than the inner diameter of the second side wall portion **14***b*. The step portion **14***d* joins the first side wall portion **14***a* to the second side wall portion **14***b*. The inward extending portion **14***f* is in a flange shape.

The inner diameter of the first side wall portion **14***a* may be the same as the inner diameter of the second side wall portion **14***b*. Moreover, the step portion **14***d* may not be provided.

As illustrated in FIG. **25**, a screw thread th**2** is provided on the inner circumferential surface of the first side wall portion **14***a*. The screw thread th**2** is a female thread. The screw thread th**2** is fitted into the screw thread th**1** of the ring member **50**. The screw thread th**1** and the screw thread th**2** can be screwed with each other. That is, the ring member **50** can be attached to the first side wall portion **14***a* by screwing. It is noted that in the present application, the screw thread th**2** is omitted in some of the drawings.

The socket housing portion **14** includes a first opening K**1**. The first opening K**1** is opened to the outer side of the head. The first side wall portion **14***a* forms the first opening K**1**. The socket **10** can be housed in the socket housing portion **14** through the first opening K**1**. The socket **10** is passed through the first opening K**1**, and disposed on the socket housing portion **14**.

As illustrated in FIGS. **18** to **21**, the outer diameter of the main body portion **10***a* is substantially the same as the inner diameter of the second side wall portion **14***b*. The outer surface of the main body portion **10***a* contacts the inner circumferential surface of the second side wall portion **14***b*.

The socket **10** is supported on the inward extending portion **14***f* from the lower side. The diameter of the through hole **14***e* is smaller than the outer diameter of the bottom face of the socket **10**. The socket **10** does not drop into the head **4**. The weight of the socket housing portion **14** is reduced because of the through hole **14***e*.

As illustrated in FIGS. **18** to **21**, the ring member **50** is disposed so as to block a part of the first opening K**1**. The ring member **50** is disposed so as to block the edge of the first opening K**1**. The held portion **10***b* is positioned on the lower side of the ring member **50**. The outer diameter of the held portion **10***b* is greater than the inner diameter of the ring member **50**. The socket **10** cannot pass through the ring member **50**. The ring member **50** controls the falling off of the socket **10**. The ring member **50** controls the falling off of the socket **10** out of the first opening K**1**. The ring member **50** prevents the socket **10** from falling off.

As illustrated in FIGS. **18** to **21**, the held portion **10***b* is supported by the step portion **14***d* from the lower side. The held portion **10***b* is held between the step portion **14***d* and the ring member **50**. The screwing amount of the ring member **50** can adjust the force of holding the held portion **10***b*. As the amount of the ring member **50** screwed is increased, the held portion **10***b* is more strongly held.

The held portion **10***b* is pressed by the ring member **50**. By the press, the held portion **10***b* is compressively deformed. By the press, the fixing of the socket **10** is further reliably attained. The ring member **50** reliably fixes the socket **10** in a simple structure.

The range of providing the screw thread th**1** and the screw thread th**2** in the axial direction is set so as to allow the press by the ring member **50**.

The ring member **50** suppress the falling off of the socket **10** by the effect of reducing the first opening K**1** and the effect of pressing the socket **10**.

The held portion **10***b* may not be in a flange shape. For example, the outer diameter of the socket **10** may be constant on the lower side of the held portion **10***b*. In this case, the inner shape of the socket housing portion **14** is also changed correspondingly to the outer shape of the socket **10**. For example, the inner diameter of the second side wall portion **14***b* is made the same as the first side wall portion **14***a*. In the embodiment, the held portion **10***b* is in a flange shape, so that the volume of the socket **10** is reduced. Thus, the weight of the socket **10** is reduced.

The ring member **50** is mechanically joined to the head main body h**1**. As described above, in the embodiment, the mechanical joining is screw joining. As compared with adhesive joining, the mechanical joining is excellent in reliability. The mechanical joining is excellent in impact resistance. The ring member **50** is unlikely to fall off because of the mechanical joining. Thus, the falling off of the socket **10** is effectively suppressed. The mechanical joining includes screw joining and fitting.

As described above, the ring member **50** includes the second opening K**2**. The weight body **12** can be passed through the second opening K**2**. The ring member **50** suppresses the falling off of the socket **10** while allowing the weight body **12** to be inserted into the socket **10**.

The screw joining is released to detach the ring member **50**. The ring member **50** is detachably attached. The socket **10** may be fixed to the head main body h**1** with an adhesive, for example, or the press by the ring member **50** may be combined with an adhesive. The socket **10** may be fixed to the head main body h**1** only using the ring member **50**. In the case where no adhesive is used, the socket **10** is replaceable. That is, the ring member **50** is detached, and the socket **10** can also be detached. Thus, it may be fine that the socket **10** can be detached by detaching the ring member **50**.

As described above, the socket **10** is formed of a polymer. The socket **10** is provided between the socket housing portion **14** and the weight body **12**. The socket **10** prevents the weight body **12** from contacting the socket housing portion **14**. When the weight body **12** contacts the socket housing portion **14**, an unusual sound can be made. Since the polymer socket **10** is provided, the occurrence of the unusual sound is suppressed.

As described above, the elastic modulus Es of the socket **10** is smaller than the elastic modulus Eh of the head main body h**1**. The elastic modulus Es of the socket **10** is smaller than an elastic modulus Ea of the socket housing portion **14**. The socket **10** of a low elastic modulus can effectively relax an impact applied to the weight body **12**. Thus, the occurrence of an unusual sound is further suppressed. It is noted that in the present application, the elastic modulus means Young's modulus.

As illustrated in FIGS. **18** to **21**, the intermediate portion **10***c* of the socket **10** is positioned on the inner side of the ring member **50**. The intermediate portion **10***c* is positioned between the ring member **50** and the weight body **12**. The intermediate portion **10***c* prevents the weight body **12** from directly contacting the ring member **50**. The intermediate portion **10***c* suppresses the occurrence of an unusual sound.

The ring member **50** contacts at least a part of an outer side surface **10***d* of the intermediate portion **10***c*. In the embodiment, the outer side surface **10***d* is substantially a circumferential surface. More correctly, the outer side surface **10***d* is a circular conical surface. The ring member **50** contacts the outer side surface **10***d* on a part of the outer side surface **10***d* in the circumferential direction. The ring member **50** may contact the outer side surface **10***d* entirely on the outer side surface **10***d* in the circumferential direction.

The ring member **50** contacts the outer side surface **10***d*, so that vibrations of the weight body **12** can be suppressed. This point will be described. Here, let us consider a gap X between the intermediate portion **10***c* and the weight body **12** (see FIG. **18**). In the case where the gap X is excessively large, the weight body **12** is apt to vibrate. Specifically, since the head portion **28** is at a position apart from the engaging portion **32**, the weight body **12** is apt to vibrate. From the viewpoint of preventing the weight body **12** from falling off, excessive vibrations of the weight body **12** are not preferable. From this viewpoint, preferably, the gap X is small. The inner diameter of the intermediate portion **10***c* can be designed in such a way that the gap X is substantially zero. However, in this case, a problem of the shaping errors of the socket **10** possibly arises. That is, in the case where the intermediate portion **10***c* is excessively small due to shaping errors, the intermediate portion **10***c* can interfere in inserting and rotating the weight body **12**. From this viewpoint, preferably, a slight gap X is provided in the design value.

On the other hand, the outer diameter and inner diameter of the intermediate portion **10***c* are sometimes increased due to the errors. In this case, the gap X can be excessively larger than the design value. However, the inner diameter of the ring member **50** regulates the outer diameter of the intermediate portion **10***c*. Since the ring member **50** contacts the outer side surface **10***d*, the gap X is prevented from being excessively large. Thus, vibrations of the weight body **12** can be suppressed.

Since the ring member **50** contacts the outer side surface **10***d*, the outer displacement of the outer side surface **10***d* is suppressed. The displacement of the outer side surface **10***d* is suppressed, so that the displacement of the weight body **12** can also be suppressed. Thus, the displacement of the outer side surface **10***d* is suppressed, so that vibrations of the weight body **12** can be effectively suppressed. The weight body **12** whose vibrations are suppressed is unlikely to fall off.

As illustrated in FIGS. **18** to **21**, a space sp**1** is provided between the ring member **50** and the socket **10**. The space sp**1** is provided between the ring member **50** and the held portion **10***b*. A part of the lower surface (the lower surface **52***b*) of the ring member **50** contacts the held portion **10***b*, and the other portion (the lower surface **54***b*) of the lower surface of the ring member **50** are apart from the held portion **10***b*. Since the lower surface **54***b* is apart from the held portion **10***b*, the space sp**1** is formed. The space sp**1** is provided between the ring member **50** and the intermediate portion **10***c*. The space sp**1** is in a substantially annular shape. The space sp **1**contributes to a reduction in the weight of the ring member **50**.

As described above, the ring member **50** presses the held portion **10***b*. More specifically, the lower surface **52***b* of the outer circumferential portion **52** presses the held portion **10***b*. Meanwhile, the lower surface **54***b* of the inner circumferential portion **54** does not contact the held portion **10***b*. The space sp**1** is formed between the lower surface **54***b* and the held portion **10***b*. Thus, the ring member **50** has a shape in which the held portion **10***b* can be pressed and the space sp**1** can be formed. Therefore, the ring member **50** can firmly fix the socket **10** while attaining a reduction in the weight.

In the present application, the specific gravity of the head main body h**1** is G**1**, the specific gravity of the attachment member **11** (the ring member **50**) is G**2**, and the specific gravity of the socket **10** is G**3** . In the embodiment, the specific gravity G**1** is greater than the specific gravity G**2**. In other words, the specific gravity G**2** is smaller than the specific gravity G**1**. Thus, a reduction in the weight of the attachment member **11** is attained. Because of a reduction in the weight of the attachment member **11**, a large mass can be allocated to the weight body **12**. Therefore, the degree of freedom of adjusting the position of the center of gravity of the head is improved.

In the embodiment, the specific gravity G**2** of the attachment member **11** is greater than the specific gravity G**3** of the socket **10**. The attachment member **11** of a high specific gravity is disposed on the sole side of the socket **10**. Thus, the position of the center of gravity of the head **4** is provided at a lower position.

As illustrated in FIG. **17**, the cross-sectional shape of the engaging portion **32** is in a substantially rectangular shape. The term “substantially” means that the modification of the corner is allowed. A typical example of a substantially rectangular shape includes a rectangle with rounded corners as in the embodiment. Another example of a substantially rectangular shape includes a rectangle with beveled corners.

The cross-sectional shape of the engaging portion **32** may be N-fold symmetry in which the axis line Z is the rotation axis. N is an integer of one or greater and four or less, for example. In a substantially rectangular shape in the embodiment, N is two. That is, the substantially rectangle is in two-fold rotation symmetry.

The N-fold rotation symmetry means that a shape after rotated by an angle of 360/N degrees about the rotation axis is matched with the shape before rotated, where N is a natural number. In other words, N is an integer equal to or greater than one. Preferably, N is an integer of one or greater and four or less. It is noted that in the general definition of rotation symmetry, N is an integer equal to or greater than two. However, in the present application, N includes one. In the general definition, rotation symmetry is not provided in the case where N is one. However, N may be one in the present application. That is, in the present application, the cross-sectional shape of the engaging portion **32** may be in “one-fold symmetry”.

In Japanese Utility Model Registration Publication No. 3142270 described above, the cross-sectional shape of the engaging portion is in a substantially square shape. In Japanese Utility Model Registration Publication No. 3142270, N is four. In the case where the cross-sectional shape of the engaging portion is in a substantially square shape, the hole **16** and the engaging portion **32** of the socket **10** are relatively easily designed. Moreover, in the case where N is four, the circumferential positions of the weight body **12** that can be fitted into the first hole portion **18** can also be four. When the weight body **12** is inserted into the hole **16**, it is necessary to fit the engaging portion **32** into the first hole portion **18**. Because of the fitting, it is necessary to rotate the weight body **12**. Since N is four, the amount of rotation of the weight body **12** for the fitting can be suppressed. This amount of rotation is suppressed, so that the weight body **12** can be easily inserted into the hole **16**. On the other hand, as illustrated in FIGS. 5 to 7 in Japanese Utility Model Registration Publication No. 3142270, in the case where the cross-sectional shape of the engaging portion is in a substantially square shape, the reverse rotation suppressing portion Rx and the excess rotation suppressing portion Ry are apt to be decreased in size as compared with the case where N is equal to or less than three. Thus, the reverse rotation and the excess rotation described above are apt to occur. In the case where N is equal to or less than three, the reverse rotation suppressing portion Rx and the excess rotation suppressing portion Ry are likely to be increased in size. Thus, reverse rotation and excessive rotation described above are effectively suppressed. From the viewpoint of suppressing reverse rotation and excessive rotation, preferably, N is one or greater and three or less.

In the case where N is equal to or less than three, the rotation angle necessary for reverse rotation and excessive rotation is increased as well as the reverse rotation suppressing portion Rx and the excess rotation suppressing portion Ry can be increased in size. Thus, reverse rotation and excessive rotation can be effectively reduced. For this reason, the reverse rotation suppressing portion Rx and the excess rotation suppressing portion Ry are unlikely to be damaged. As a result, the socket **10** is unlikely to deteriorate even though the socket **10** is repeatedly used.

An example of the case where N is four includes a substantially square shape. An example of the case where N is three includes a substantially regular triangular shape. An example of the case where N is two includes a substantially parallelogram shape in addition to the substantially rectangular shape as in the embodiment. In the case where N is equal to or less than three, preferably, N is two. In this case, the cross-sectional shape of the engaging portion **32** is relatively simple as compared with the case where N is one. Thus, the engaging portion **32** and the socket **10** are easily designed.

In the present application, the longest rotation radius of the engaging portion **32** is R**1**. Moreover, the shortest rotation radius of the engaging portion **32** is R**2**. The radius R**1** is as described above. That is, as illustrated in FIG. **22**, the radius R**1** is the distance between the rotation center Z and the point Pf. The radius of R**2** is the distance between the rotation center Z and a point Pc. The point Pc is a point the nearest to the point Z on the outline of the section of the engaging portion **32** (see FIG. **22**).

From the viewpoint of enlarging the reverse rotation suppressing portion Rx and the excess rotation suppressing portion Ry, R**1**/R**2** is preferably equal to or greater than 1.30, more preferably equal to or greater than 1.33, and still more preferably equal to or greater than 1.36. From the viewpoint of downsizing the socket housing portion **14** and the socket **10**, R**1**/R**2** is preferably equal to or less than 1.70, more preferably equal to or less than 1.60, and still more preferably equal to or less than 1.50. It is noted that in the embodiment, R**1**/R**2** is 1.39.

In the cross-sectional view at the non-engaging position NP in FIG. **22**, a crosshatched portion expresses a cross-sectional area X of the reverse rotation suppressing portion Rx. From the viewpoint of suppressing the reverse rotation, the cross-sectional area X is preferably equal to or greater than 1.5 mm^2, more preferably equal to or greater than 2.0 mm^2, and still more preferably equal to or greater than 2.5 mm^2. From the viewpoint of downsizing the socket housing portion **14** and the socket **10**, the cross-sectional area X is preferably equal to or less than 5.0 mm^2, more preferably equal to or less than 4.5 mm^2, and still more preferably equal to or less than 4.0 mm^2. The cross-sectional area X is the cross-sectional area of a single reverse rotation suppressing portion Rx.

In the cross-sectional view at the engaging position EP in FIG. **22**, a crosshatched portion expresses a cross-sectional area Y of the excess rotation suppressing portion Ry. From the viewpoint of suppressing the over rotation, the cross-sectional area Y is preferably equal to or greater than 1.5 mm^2, more preferably equal to or greater than 2.0 mm^2, and still more preferably equal to or greater than 2.5 mm^2. From the viewpoint of downsizing the socket housing portion **14** and the socket **10**, the cross-sectional area Y is preferably equal to or less than 5.0 mm^2, more preferably equal to or less than 4.5 mm^2, and still more preferably equal to or less than 4.0 mm^2. The cross-sectional area Y is the cross-sectional area of a single excess rotation suppressing portion Ry.

In FIG. **22**, a two-directional arrow R**3** expresses the maximum height of the reverse rotation suppressing portion Rx. The height R**3** is measured along the radial direction. From the viewpoint of suppressing the reverse rotation, R**3**/R**1** is preferably equal to or greater than 0.19, more preferably equal to or greater than 0.20, and still more preferably equal to or greater than 0.21. From the viewpoint of downsizing and reducing the weight of the socket housing portion **14** and the socket **10**, R**3**/R**1** is preferably equal to or less than 0.24, more preferably equal to or less than 0.23, and still more preferably equal to or less than 0.22.

It is noted that the radial direction is the direction of a straight line Lp in FIG. **17**. The straight line Lp is a straight line intersecting with the axis line Z and perpendicular to the axis line Z.

In FIG. **22**, a two-directional arrow R**4** expresses the maximum height of the excess rotation suppressing portion Ry. The height R**4** is measured along the radial direction. From the viewpoint of suppressing the over rotation, R**4**/R**1** is preferably equal to or greater than 0.19, more preferably, equal to or greater than 0.20, and still more preferably equal to or greater than 0.21. From the viewpoint of downsizing and reducing the weight of the socket housing portion **14** and the socket **10**, R**4**/R**1** is preferably equal to or less than 0.24, more preferably equal to or less than 0.23, and still more preferably equal to or less than 0.22.

[Hardness Hs of the Socket]

From the viewpoint of reliably attaining the fixing of the weight body **12** and suppressing the occurrence of an unusual sound when hitting a ball, the hardness Hs of the socket **10** is preferably equal to or greater than D**40**, more preferably equal to or greater than D**42**, and still more preferably equal to or greater than D**45**. From the viewpoint of the abrasion resistance property, the hardness Hs is preferably equal to or less than D**80**, more preferably equal to or less than D**78**, and still more preferably equal to or less than D**76**.

The hardness Hs is measured in accordance with the regulation of "ASTM-D 2240-68" using a Shore D type hardness scale attached to an automated rubber hardness measuring device ("P1" (trade name) manufactured by Koubunshi Keiki Co., Ltd.). The shape of a measurement sample is a cube having a side length of 3 mm. Measurement is performed under a temperature of 23° C. The measurement sample is cut out from the socket **10** if possible. In the case where it is difficult to cut out the measurement sample, a measurement sample made of the same resin composition as that of the socket **10** is used.

[Polymer]

From the viewpoint of the hardness, preferably, the material of the socket is a polymer. The polymer includes a thermosetting polymer and a thermoplastic polymer. The thermosetting polymer includes a phenol resin, an epoxy resin, a melamine resin, a urea resin, an unsaturated polyester resin, an alkyd resin, a thermosetting polyurethane, a thermosetting polyimide, and a thermosetting elastomer. The thermoplastic polymer includes polyethylene, polypropylene, polyvinyl chloride, polystyrene, polytetrafluoroethylene, an ABS resin (acrylonitrile butadiene styrene resin), an acrylic resin, polyamide, polyacetal, polycarbonate, modified polyphenylene ether, polybutylene terephthalate, polyethylene terephthalate, polyphenylene sulfide, polyether ether ketone, a thermoplastic polyimide, polyamide imide, and a thermoplastic elastomer.

The thermoplastic elastomer includes a thermoplastic polyamide elastomer, a thermoplastic polyester elastomer, a thermoplastic polystyrene elastomer, a thermoplastic polyester elastomer, and a thermoplastic polyurethane elastomer.

From the viewpoint of durability, a urethane-based polymer and polyamide are preferable, and the urethane-based polymer is more preferable. The urethane-based polymer includes polyurethane and a thermoplastic polyurethane elastomer. The urethane-based polymer may be a thermoplastic polymer, or may be a thermosetting polymer. From the viewpoint of formability, a thermoplastic urethane-based polymer is preferable, and the thermoplastic polyurethane elastomer is more preferable.

From the viewpoint of formability, the thermoplastic polymer is preferable. From the viewpoint of hardness and durability, in the thermoplastic polymer, the polyamide and the thermoplastic polyurethane elastomer are preferable, and the thermoplastic polyurethane elastomer is more preferable.

The polyamide includes nylon **6**, nylon **11**, nylon **12**, and nylon **66**.

A preferable thermoplastic polyurethane elastomer contains a polyurethane component as a hard segment, and a polyester component or a polyether component as a soft segment. That is, a preferable thermoplastic polyurethane elastomer (TPU) includes a polyester-based TPU and a polyether-based TPU. A curing agent for the polyurethane component includes cycloaliphatic diisocyanate, aromatic diisocyanate, and aliphatic diisocyanate.

The cycloaliphatic diisocyanate includes 4,4'-dicyclohexylmethane diisocyanate (H_{12}MDI), 1,3-bis(isocyanatomethyl)cyclohexane (H_6XDI), isophorone diisocyanate (IPDI), and trans-1,4-cyclohexane diisocyanate (CHDI).

The aromatic di-isocyanate includes diphenylmethane diisocyanate (MDI) and toluene diisocyanate (TDI). The aliphatic diisocyanate includes hexamethylene diisocyanate (HDI).

A commercially available thermoplastic polyurethane elastomer (TPU) includes "Elastollan" (trade name) manufactured by BASF Japan Ltd.

Specific examples of the polyester-based TPU include "Elastollan C70A", "Elastollan C80A", "Elastollan C85A", "Elastollan C90A", "Elastollan C95A", and "Elastollan C64D", for example.

Specific examples of the polyether-based TPU include "Elastollan 1164D", "Elastollan 1198A", "Elastollan 1180A", "Elastollan 1188A", "Elastollan 1190A", "Elastollan 1195A", "Elastollan 1174D", "Elastollan 1154D", and "Elastollan ET385", for example.

From the viewpoint of versatility and productivity, an example of a preferable material of the socket is a resin. A fiber reinforced resin containing the polymers as a matrix may be used.

FIG. **26** is a cross-sectional view around a socket housing portion of a head according to an exemplary modification. The head includes a head main body h**10**, a socket **100**, an attachment member **101**, and a weight body **12**. The weight body **12** is as described above.

The socket **100** includes a main body portion **100***a*, a held portion **100***b*, an intermediate portion **100***c*, and a bottom face forming part **100***d*. The held portion **100***b* is positioned on the outer side of the main body portion **100***a*. The main body portion **100***a* includes a hole **16**. The hole **16** is as described above.

The head main body h**10** includes a socket housing portion **104**. The socket housing portion **104** includes an inward extending portion **104***a* and a side wall portion **104***b*. The inward extending portion **104***a* forms a flange. The inward extending portion **104***a* forms a downward surface **104***c*. The side wall portion **104***b* includes a first opening K**10**. The first opening K**10** is opened to the inner side of the head. The inward extending portion **104***a* includes a third opening K**30**. The third opening K**30** is opened to the outer side of the head.

The inner diameter of the side wall portion **104***b* is constant. On the other hand, the outer diameter of the side wall portion **104***b* is not constant. The side wall portion **104***b* includes a step surface **104***d*. The thickness of the side wall portion **104***b* is changed at the boundary of the step surface **104***d*.

The inner diameter of the inward extending portion **104***a* is constant. The inner diameter of the inward extending portion **104***a* is smaller than the inner diameter of the side wall portion **104***b*. The inner circumferential surface of the inward extending portion **104***a* is coaxial with the inner circumferential surface of the side wall portion **104***b*.

The attachment member **101** is in a substantially disc shape as a whole. The attachment member **101** includes a center portion **101***a* and an outer edge portion **101***b*. The outer edge portion **101***b* is in an annular ring shape. The outer edge portion **101***b* extends from the peripheral area of the center portion **101***a* to the upper side.

A screw thread th**3** is formed on the inner circumferential surface of the outer edge portion **101***b*. The screw thread th**3** is a female thread. A screw thread th**4** is also formed on the socket housing portion **104** correspondingly to the screw thread th**3**. The screw thread th**4** is formed on the outer circumferential surface of the side wall portion **104***b*. The screw thread th**4** is formed on the lower end portion of the side wall portion **104***b*. The screw thread th**3** is screwed to the screw thread th**3**.

Thus, the attachment member **101** is screwed to the socket housing portion **104**. As described above, screw joining is mechanical joining.

The attachment member **101** blocks the first opening K**10** . The first opening K**10** is blocked by the attachment member **101**. The attachment member **101** controls the socket **100** to move so as not to pass through the first opening K**10**. The socket **100** does not fall into the head.

The maximum outer diameter of the socket **100** is greater than the inner diameter of the inward extending portion **104***a*. The socket **100** cannot pass through the third opening K**30**. The third opening K**30** does not allow the socket **100** to pass. The socket **100** does not fall out to the outer side of the head. Meanwhile, the third opening K**30** allows the weight body **12** to be inserted into the socket **100**. The third opening K**30** does not prevent the attachment and detachment of the weight body **12**.

The held portion **100***b* includes a top surface b**1** and a lower surface b**2**. The top surface b**1** contacts the downward surface **104***c*. The lower surface b**2** contacts the attachment member **101**. The held portion **100***b* is held between the attachment member **101** and the head main body h**10**. The held portion **100***b* is pressed against the attachment member **101**. As the attachment member **101** is more screwed, the pressing force becomes greater.

By the press of the attachment member **101**, the held portion **100***b* is compressively deformed. The held portion **100***b* is compressed in the axial direction. The press of the attachment member **101** reliably fix the socket **100**.

The socket **100** is inserted from the inner side of the head into the socket housing portion **104**. The top surface b**1** contacts the downward surface **104***c*, and then the inserted socket housing portion **104** is positioned in the axial direction. In the positioned state, the bottom face of the socket **100** protrudes on the outer side of the head beyond the first opening K**10**. Subsequently, the attachment member **101** is screwed. When the attachment member **101** is more screwed, the top surface of the center portion **101**a contacts the bottom face of the socket **100**. When the attachment member **101** is further more screwed, the attachment member **101** presses the socket **100**.

As described above, the thickness of the side wall portion **104**b is changed at the boundary of the step surface **104**d. The outer diameter of the side wall portion **104**b is changed at the boundary of the step surface **104**d. The outer diameter on the upper side of the step surface **104**d is increased. The step surface **104**d may be eliminated. That is, the outer diameter of the side wall portion **104**b may be constant. For example, the outer surface of the socket housing portion **104** may be formed as depicted by a long dashed double-short dashed line Hp**1**. In the exemplary modification illustrated by the long dashed double-short dashed line Hp**1**, the outer diameter of the socket housing portion **104** is constant. Since the outer diameter of the side wall portion **104**b is made constant, the structure of the socket housing portion **104** is simplified, and the weight of the socket housing portion **104** can be reduced. Moreover, in the exemplary modification illustrated by the long dashed double-short dashed line Hp**1**, the outer diameter of the socket housing portion **104** is constant. Thus, the effects of simplification and a reduction in the weight are further improved.

EXAMPLES

In the following, the effects of the present invention will be clarified by examples. However, the present invention should not be interpreted in a limited way based on the description of the examples.

First Example

A head having the same structure as that of the head **4** was prepared as below.

A face member was obtained by pressing a rolled material made of a titanium alloy (Ti-6Al-4V). A body was obtained by casting using a titanium alloy (Ti-6Al-4V). The body included a socket housing portion. The obtained face member was welded to the body to obtain a head main body.

A socket was obtained by injection molding. A thermoplastic polyurethane elastomer was used for the material of the socket. Specifically, a product material obtained by mixing "Elastollan 1164D" with "Elastollan 1198A" at a weight ratio of 1:1 was used. The cross-sectional area X was 3.27 mm^2. The cross-sectional area Y was 3.27 mm^2.

A tungsten nickel alloy (W—Ni alloy) was used for the material of a weight body. The W—Ni alloy was molded by powder sintering to obtain the weight body. The mass of the weight body was 11 g.

The socket was inserted into the socket housing portion. The socket was inserted from the outer side of the head. The socket was bonded to the socket housing portion using an adhesive.

"DP460" (trade name) manufactured by Sumitomo 3M Ltd. was used for the bonding. Moreover, the ring member was attached by screw joining. The ring member was screwed until the held portion was pressed.

The weight body was attached to the socket using the tool **60** described above. As a result, a head according to the first example was obtained. The head according to the first example and a grip were attached to a shaft, and a club according to the first example was obtained.

Second Example

A club according to a second example was obtained similarly to the first example except that no adhesive was used in attaching the socket.

Third Example

A socket housing portion and a socket were modified to the form illustrated in FIG. **26**. The socket was disposed on the socket housing portion in a body to which a face member was not welded yet. The socket was inserted into the socket housing portion from the inner side of the head. In attaching the socket, no adhesive was used. Subsequently, an attachment member was screwed. The attachment member was screwed until the held portion was pressed. Subsequently, the face member was welded to the body. A club according to a third example was obtained similarly to the first example except the points described above.

[Durability Test]

The club was attached to a swing robot, and a commercially available two-piece ball was hit for 10,000 times. The head speed was 54 m/s. In any of the examples, the fixing of the socket to the weight body was maintained during hitting the ball for 10,000 times.

The invention described above can be applied to all golf clubs. The present invention can be used for a wood type club, a utility type club, a hybrid type club, an iron type club, and a putter club, for example.

The description hereinabove is merely an illustrative example, and various modifications can be made in the scope not deviating from the principles of the present invention.

What is claimed is:

1. A golf club head comprising:
a head main body;
an attachment member;
a socket; and
a weight body, wherein:
the head main body includes a socket housing portion;
the socket is attached to the socket housing portion;
the socket housing portion includes a first opening through which the socket can be housed;
the attachment member is mechanically joined to the head main body;
the attachment member is disposed so as to block at least a part of the first opening;
the attachment member controls falling off of the socket from the first opening;
the socket includes a held portion;
the held portion is pressed by the attachment member;
the socket is formed of a polymer whose elastic modulus is lower than an elastic modulus of the head main body; and
the weight body is detachably attached to the socket.

2. The golf club head according to claim **1**, wherein:
the first opening is opened to an outer side of the head;
the attachment member is a ring member;
the ring member is disposed so as to block a part of the first opening; and
the ring member includes a second opening through which the weight body can be inserted into the socket.

3. The golf club head according to claim **2**, wherein:
relative rotation is enabled between the weight body and the socket;

the relative rotation allows the weight body to be placed at an engaging position and a non-engaging position;

the ring member includes an indication; and

the indication facilitates determination whether the weight body is at the engaging position or not.

4. The golf club head according to claim **2**, wherein:

the socket further includes an intermediate portion; and

the intermediate portion is positioned between the ring member and the weight body.

5. The golf club head according to claim **4**, wherein the ring member contacts at least a part of an outer side surface of the intermediate portion.

6. The golf club head according to claim **1**, wherein:

the first opening is opened to an inner side of the head;

the socket housing portion further includes a third opening opened to an outer side of the head; and

the third opening allows the weight body to be inserted and controls falling off of the socket to the outer side of the head.

7. The golf club head according to claim **1**, wherein the held portion is held between the attachment member and the head main body.

8. The golf club head according to claim **1**, wherein a space is provided between the held portion and the attachment member.

9. The golf club head according to claim **1**, wherein:

the socket further includes an intermediate portion;

the intermediate portion is positioned between the attachment member and the weight body; and

the attachment member does not directly contact the weight body.

10. The golf club head according to claim **1**, wherein:

the socket housing portion includes a bottom portion;

the bottom portion includes an inward extending portion and a through hole; and

the inward extending portion supports a bottom face of the socket.

11. The golf club head according to claim **1**, wherein when a specific gravity of the head main body is G**1**, a specific gravity of the attachment member is G**2**, and a specific gravity of the socket is G**3**, the specific gravity G**1** is greater than the specific gravity G**2**, and the specific gravity G**2** is greater than the specific gravity G**3**.

12. The golf club head according to claim **1**, wherein:

the socket housing portion includes a side wall portion; and

an outer diameter of the side wall portion is constant.

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